v. 12 has only 10 nos. bind 2 vol. in 1

t+i

Eng. Lib.

COMPRESSED AIR

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XII DECEMBER, 1907 No. 10

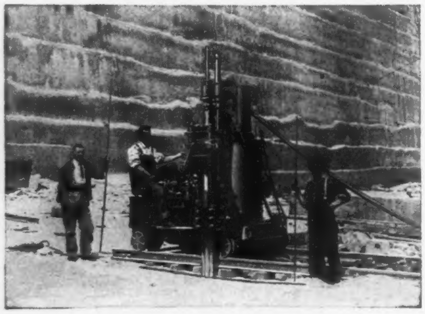
Published by THE COMPRESSED AIR MAGAZINE CO., Easton, Pa.

NEW YORK, Bowling Green Building. LONDON, 114 Queen Victoria Street.

Classified Buyers' Guide, Page 6. Index to Advertisers, Page 4.

SULLIVAN STONE CHANNELERS

AT PANAMA



Sullivan "Y-8" Air Channeler in No. 6 quarry of Cleveland Stone Co., So. Amherst, Ohio.

The Isthmian Canal Commission has ordered 24 Sullivan Class "Y-8" air channelers. These machines will be used in cutting the rock walls of the "wet prism," in the Culebra cut, nine miles long, between Bas Obispo and Pedro Miguel, and also in cutting the great locks at La Boca and Mira Flores.

This is the largest single order for channelers ever placed.

SULLIVAN MACHINERY CO.,

RAILWAY EXCHANGE
CHICAGO, ILL.

BIRMINGHAM, Ala. · BUTTE · CLAREMONT, N. H. · DENVER · EL PASO · JOHANNESBURG · JOPLIN, MO. · KNOXVILLE · NEW YORK · PITTSBURG · PARIS, FRANCE · ST. LOUIS · SAN FRANCISCO · SALT LAKE · SPOKANE

INDEX TO ADVERTISERS.

REPAIRS CONSUME PROFITS

A LIMITED WATER SUPPLY

Decreases the output. Install a 20th Century Air Pump and increase your water supply 50 per cent.

Easy to Operate.

Nothing to Wear Out. Write for Catalogue

Harris Air Pump Company

215 STATE LIFE BUILDING
INDIANAPOLIS, IND.

CLASSIFIED BUYERS' GUIDE

Air Cylinder Oil.
Fiske Bros.' Refining Co.

Air Lift Pumps.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Air Gauges.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Sargent Steam Meter Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Air Receivers.
American Diamond Sand Blast Co.
Blaisdell Machinery Co.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Porter Co., H. K.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.

Air Tanks.
American Diamond Sand Blast Co.
Blaisdell Machinery Co.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Porter Co., H. K.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Aftercoolers, Air.
Blaisdell Machinery Co.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Porter Co., H. K.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Angle Gears.
Cleveland Pneumatic Tool Co.

Barrow Wheels.
W. J. Clark Co.

Belt Dressings.
Jos. Dixon Crucible Co.

Blowers.
Cameron Steam Pump Works, A. S.
General Compressed Air and Vacuum Machinery Co.

Blowing Engines.
Cooper Co., C. & G.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.

(Continued on page 12.)

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XII DECEMBER, 1907 No. 10

CAISSON WORK FOR THE PARIS SUBWAY

The built or projected lines of urban transit in Paris cross the Seine five times upon bridges of various design. One line, however, traversing the central portion of the city, passes under the river, and its construction has involved the sinking of metallic caissons of large size and of unusual design. The plan first proposed was to have two separate tunnels driven at a suitable depth by the compressed air shield system. This would have necessitated the adoption of a level at least ten feet lower than was required for the system adopted, while at the same time the latter would permit the use of a single tube for both tracks instead of a separate tube for each.

The tunnel was formed by sinking a number of caissons in the bed of the river and connecting them to form the continuous tube required. Altogether three distinct methods of construction were used for the line. For the shore sections, running to a certain distance from the banks, the tunnel was built or driven by the aid of a compressed air shield, and, as the second method, the caissons were sunk in the bed of the river to the required depth and in correct positions to connect. A third method is to be used later when the work is carried under the line of another road already built and in operation. To prevent any sinking of the road above it at this point, the freezing process is to be employed. There is an island in the River Seine, with a passenger station

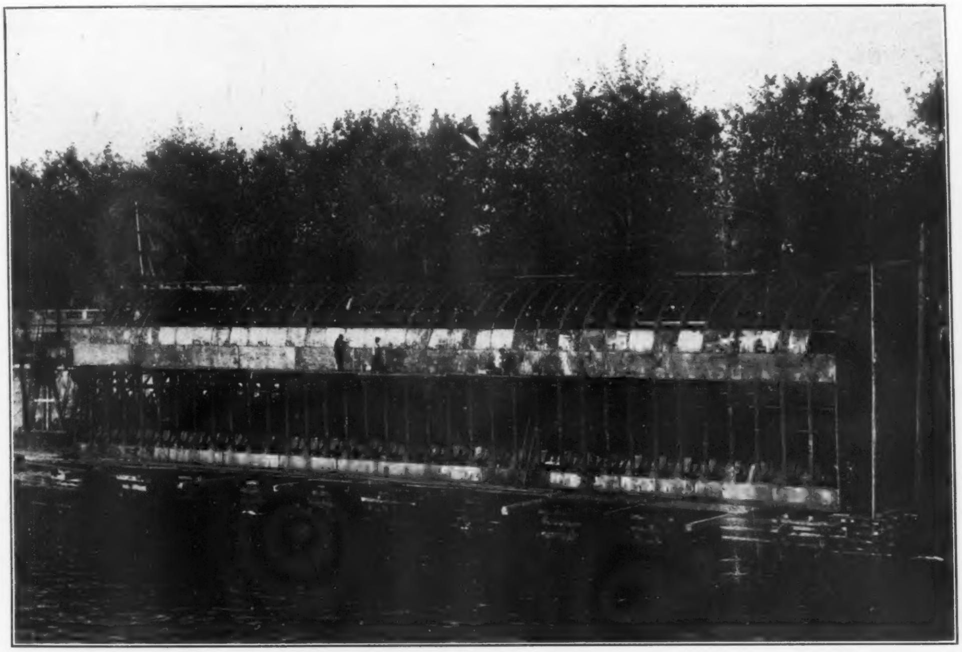


FIG. I. SIDE VIEW OF PARIS TUNNEL CAISSON.

for the subway line, the station also being formed by the sinking of a group of immense caissons between the ground and water levels. There are three sections of the tunnel caisson in the large arm of the river and two sections in the narrower arm.

The half-tones show clearly the caisson construction. Each section is formed of two principal parts, the tunnel proper and an outer framework which forms the actual caisson. The tunnel is approximately elliptical in section and is composed of iron rings. Each ring is made up of a series of cast iron voussoirs bolted together and the rings then bolted to each other with layers of treated wood between for a water-tight packing. Around this elliptical tube is built a metallic shell which in the lower part of it forms the rectangular caisson. The frame of this shell is formed of a series of curved ribs of channel bar outside the tunnel tube and braced at a certain distance from and nearly parallel with it by cross braced iron work. These ribs do not run around under the elliptical tube, but, passing the center or horizontal axis, they extend vertically downward, thus forming the sides of the caisson, and extending some distance below the bottom of the tunnel tube they thus form the compressed air chamber in which the men work to make the necessary excavation to allow the structure to sink to the required depth. Over the ribs is placed a sheet-iron covering which forms an external air-tight shell, the ends also of the caisson being thus closed.

The caisson is floated and towed to its place, piles being driven to guide it vertically during the sinking operation. The semi-elliptical space between the tunnel tube and the sheet-iron sides is filled up with cement beton, the top plating having been left off for the purpose. As the ground is excavated within and under the caisson it is gradually lowered to its proper level below the river bed, the tunnel tube having been ballasted with water to give the needed weight and steadiness. When finally in place the caisson is filled with concrete, the shafts at the side, with the air locks for the passage of men and material, are removed, and after all the connections are made the water is pumped out of the tunnel tube. The ends of the caissons lie about five feet apart, and this space is filled by a small caisson which is sunk last. The removal of the end plates of all the sections leaves the continuous tube.

There is a double pneumatic interest in this undertaking, as compressed air was employed not only in the sinking of the caissons, but also in their construction, both of the half-tones showing Haeseler pneumatic riveters in use upon the frames and shells.

REFRIGERATION AS A SUPPLEMENTARY FUNCTION OF THE POWER PLANT

By Joseph H. Hart, Ph. D.*

Refrigerating machines may be classified into three groups: those employing air as a refrigerant; those employing the mechanical phenomena of absorption and solution of ammonia by water, and those using liquefiable gas. The air machine is clean and odorless and is somewhat in use on shipboard. It utilizes the process known as balanced expansion, whereby the air is cooled by doing work in a cylinder. Its size, weight and cost and large consumption of power are serious drawbacks to its wider use, and it is now recognized that its field is limited to places where the use of other types is prohibited.

The absorption machine has a rather complicated mechanism. There are no moving parts except a small slow speed pump and it possesses a distinct advantage on this account. Its agent is ammonia and it was generally regarded up to about the year 1895 as an extremely inefficient process.

The liquefiable gas machine was considered the most efficient, the simplest and most convenient. A gas was liquefied by mechanical compression, followed by cooling; this liquid was then allowed to evaporate and absorb its latent heat of liquefaction from surrounding bodies, and the process was made continuous.

The absorption machine, so-called, which utilized water in conjunction with ammonia gas, was the first practical refrigerating machine; but later it came into considerable disrepute on account of its remarkable inefficiency. The gas was produced from the aqua ammonia by steam coils in a generator somewhat similar in construction to the modern boiler. The pressure was increased by means of heat until the gas could be liquefied with cold water, and it was then evaporated in a manner identical with that of the ammonia compression type.

---

*Abstract from Cassier's Magazine.

The expanded gas, instead of being conveyed into a compressor, as in the latter system, was absorbed by cold water or weak aqua ammonia. This system requires five distinct units: the generator, where the gas is produced; the dehydrator, where the excess water vapor carried over by the gas is condensed and removed; the condenser, which consists of pipes having cold water flowing over them and in which the gas is changed to ammonia liquid; the expansion coils or shell cooler, in which the refrigeration is produced; and the absorber, which absorbs the gas back into the weak aqua ammonia. Further, an ammonia pump must be installed to force this liquid back into the generator, thus making the process continuous.

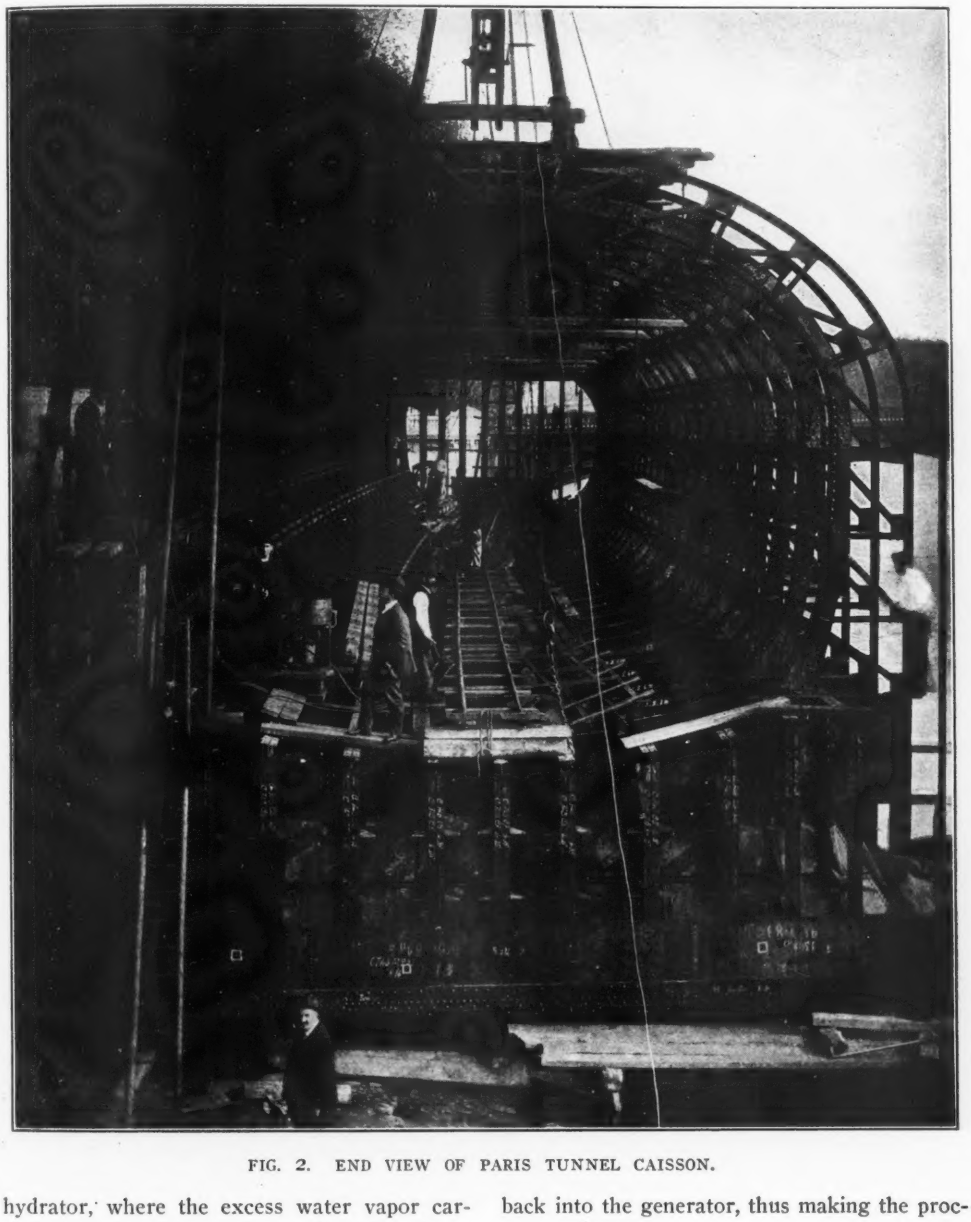


FIG. 2. END VIEW OF PARIS TUNNEL CAISSON.

The compression system, on the other hand, utilizes simply a compressor and condenser and the refrigerating apparatus or shell cooler.

This mechanical compression type was formerly superior, although it depends on the operation of a compressor which is mechanically of low efficiency. Both types of machines, however, are dependent for their efficiency upon design to an extent which was not realized until recently, and the situation exists to-day that the absorption system is the superior in many ways when used in large units.

The absorption system has its efficiency limited directly by the action of the dehydrator. If water vapor is carried over with the gas and not separated, it condenses in the condenser in the production of liquid ammonia and combines there directly with it, forming strong aqua ammonia; the refrigerating power of the ammonia being counterbalanced by the heat of combination at this point. Thus the entire problem in the absorption system depends upon the design of the generator and its efficiency in producing rapidly comparatively pure ammonia gas without water vapor, and upon the efficiency of the dehydrator in removing the residue of the water vapor before it becomes objectionable. The design of the absorption system was not fully studied until within the last decade. Machines of both types depend absolutely for their efficiency on their design. An absorption plant may operate with a production of no refrigeration and a compression plant may do the same.

The absorption machine employs the latent heat in the steam for the production of ammonia. A compression type utilizes the expansive force of steam only, and hence superheated compound condensing engines are the rule in large installations of this type. We thus come to the anomalous condition that the absorption machine can utilize exhaust steam very efficiently, whereas the compression plant does not utilize the heat of the exhaust at all. The claim is often made that the absorption machine requires more heat in its operation than the compression plant, and while this is true, when the quantity of heat taken from the boiler is considered the absorption system is still much superior. Thus in large units—in the production of ice, for example—a compression plant operates generally on an 8 to 1 basis; that is, 8 tons of ice produced to 1 ton of coal consumed. An absorption system under the same conditions can operate on an 11 to 1 basis, whereas a combination plant of the same total capacity for compression and for absorption, the exhaust steam from the compressor operating the absorption system, will operate on a 14 to 1 basis. These figures in general have a 50 per cent. range of applicability, depending upon maintenance of plant and method of operation; but there is no doubt, in large units of 100 tons capacity or more, that the absorption system, or, better, a combination plant is much superior. This is in complete contradiction to the generally accepted opinion ten years ago, and is due to improvement in design of the absorption system.

This brings us to a remarkable condition in the engineering field. It shows a further application of the utilization of exhaust steam never before seriously considered. Exhaust steam has been used generally for heating purposes and in some isolated cases for drying various materials. Its application to mechanical refrigeration in power plant production has progressed to a certain stage. It has been generally recognized that such units as the lighting or trolley systems have excess loads in the morning and evening. Formerly this was taken care of by storage batteries, but their rapid deterioration and general cost of maintenance was such that it has been found preferable to operate a full size plant for the load at maximum. This is due partl to the increased efficiency of large plants and to the necessity of a choice between two evils. This latter situation presented a large excess power available at slack time and this excess has in some cases been sold to small refrigeration consumers operating their own plants. Mechanical refrigeration possesses this further advantage in this field. It can be operated intermittently. Thus by the use of a large brine storage tank refrigeration can be produced in the brine and kept here for long periods of inactivity with small waste and utilized when wanted. Thus the power plant in its development has aided the development of a large number of small unit refrigerating systems by the furnishing of sufficient power at minimum cost at irregular intervals.

Further, owing to the ability of mechanical refrigeration to operate intermittently and in reality to take the place of the storage battery in the storage of energy, it has found a place in the modern plant. Thus many small trolley and lighting systems operate a refrigerating or cold storage plant as well. The excess

current being turned into refrigeration when not needed and the cold brine carrying this system over the inactive period when power was needed along other lines. This has proved extremely efficient, and in many of the smaller cities such plants are in active operation.

The advent of the absorption system with its remarkable increase in efficiency threatens to produce a change in the present conditions. Modern power plants in large units require complicated prime movers using superheated steam and generally of the compound condensing type, whose cost of maintenance and high first cost is often almost prohibitory. The absorption system cannot use efficiently high pressure superheated steam. The compression plant itself is inefficient in the production of refrigeration. Hence, it, in turn, will be displaced for large units, and we shall have the rather anomalous condition of large refrigerating concerns with excess power for sale, using simply plain slide-valve engines of low efficiency and large steam consumption. Such a plant could sell power as a by-product in quantities and at prices such that the ordinary unit in this field could not compete. Further, the modern power plant has an additional by-product available in the utilization of its exhaust steam in the production of mechanical refrigeration. The interrelations between these two engineering developments are at their inception and time only can develop the exact situation. However, conditions are such at present as to point almost conclusively to a radical change in their interrelations and a complete innovation in the production of power.

LIFE AND WORK OF THE "SAND HOG"

"Excavating Skyscraper Foundations," by T. Kennard Thomson, in the *Engineering Magazine* for October, is an excellent article throughout. It is a clear, accurate and eminently readable account of the development and present status of this important line of work by an engineer who has contributed materially to the improvement of the means and methods employed. The following having to do with the men who work under pressure in the caissons requires no commendation from us.

Sand hogs work in eight-hour shifts—that is, three gangs in twenty-four hours, each gang taking half an hour for lunch and seven and one-half hours for actual work, for which they receive $3.50 a day, until the air pressure exceeds 20 pounds per square inch. As the pressure increases the pay increases, but the hours of labor decrease until at 45 pounds (in addition to atmospheric) the men only work one and one-half hours a day, and even that is divided into two shifts of three-quarters of an hour each and four hours apart; this is all the men can stand, and even then there is great danger of the bends, or worse, of being paralyzed. Many can not even stand the light pressure.

The first effect generally noticed when the air is let into the lock is the pressure of the air on the ear drums, and if this pressure is not quickly equalized, the ear drum is ruptured, of course, for life. At other times this plugged sensation results in blood vessels being ruptured in the head which danger is much greater if the person has a cold to start with. In fact, if one has a cold or anything wrong with his heart or lungs, he has no business to try to enter the lock at all. Even men in apparent perfect condition can not always stand it. A lock might be described as a small room with two doors like the vestibule of a house, so that if one enters and shuts the outside door before opening the inside door only the amount of air contained between the two doors is lost in passing in or out. It is necessary to have an air lock to prevent all the air escaping from the air chamber every time men or material pass through the lock, for if all the compressed air were allowed to escape from the working chamber, even for a very short time, the chamber would quickly fill up with mud and water, with probably disastrous results to the adjoining buildings, to say nothing of the loss of human life.

When the compressed air is allowed to enter the lock too quickly, and sometimes even when considerable time has been taken in entering and leaving the lock, it is supposed that the air bubbles force the blood away from the surface and then, when coming out of the compression, many of the bubbles remain in the system, which results in the "bends," a very painful experience. The attack is usually in the arm or legs. The longer one stays in compressed air and the more exertion taken in it, the greater the risk of the bends, which, however, often do not make themselves felt for several hours after coming out, although some

claim that they can tell that they are getting the bends while still in the air chamber. The worst form of caisson disease is paralysis, from which some die at once, some recover, and others are afflicted for the rest of their lives; and which it will be none can tell. Many of the old watchmen seen on these jobs, humping around with a cane, are such victims.

A schoolgirl was once asked where could you walk the faster, on top of a high mountain, where the pressure is very much lighter than what we call atmospheric (nearly 15 pounds per square inch) or down in a caisson where one has to carry, say 20 to 40 pounds, on every square inch of the body in addition to the atmospheric. At first she thought on top of the mountain, but quickly corrected herself by saying: "Of course not, for more work could be done in the compressed air on account of the great supply of oxygen." The excess of oxygen not only gives the men great energy and appetites—you see seldom a thin sand hog—but it also makes candles, matches, cigars, etc., burn much faster; in fact, frequently, men have blown out a candle and put it in their pockets, only to find their coat on fire in a few minutes. One seldom sees an old sand hog; they must burn up their energies. It has often been a matter of comment that even the best of sand hogs are about useless if given an outside job; whether they lose their inclination or ability to do good work, I know not.

SOME PECULIARITIES OF IMPLOSION

Every one knows what an explosion is; but its opposite, an implosion, is less familiar. At great depths in the sea the conditions are favorable for its production. At twenty-five hundred fathoms the pressure is, roughly speaking, three and a half tons to the square inch; that is to say, fifty to a hundred times greater than the pressure exerted by the steam upon the piston of a powerful engine. An interesting experiment to illustrate the enormous force of this deep-sea pressure was not long ago made on the Albatross, a government vessel engaged in deep-sea exploration. A thick glass tube several inches in length full of air was hermetically sealed at both ends. This was wrapped in flannel and placed in one of the wide copper cylinders, used to protect deep-sea thermometers when they are sent down with the sounding apparatus. The copper cylinder had holes bored in it, so that the water had free access inside, around the glass. The case was then sent down to a depth of two thousand fathoms, and drawn up again. It was found that the cylinder was bulged and bent inward, just as if it had been crumpled inward by being violently squeezed. The glass tube itself, within its flannel wrapper, was reduced to a fine powder, almost like snow. The glass tube, it would seem, as it slowly descended, held out long against the pressure, but at last suddenly gave way, and was crushed by the violence of the action to a fine powder. This process, exactly the reverse of an explosion, is termed an implosion.

REFRIGERATION ON THE LUSITANIA

Two distinct and complete sets of refrigerating machinery are installed upon the Lusitania, one for the steamer's own provisions and another for use on any cargo which might require refrigerating. The provision chambers are situated on what is known as the lower deck, and are insulated with granulated cork and a special paper impervious to damp, with the necessary casing of white pine boards. These chambers have a total capacity of about 13,000 cu. ft., and are divided into compartments, each compartment for the storing of a separate provision. The refrigerating machinery for the provision chambers is located near the forward end of the main engine room, at the level of the main deck, uses CO_2 as the refrigerant, and is in duplicate. The two compressors are placed horizontally, and work from a main shaft, which is driven direct by an electric motor. The cargo cold storage comprises six large rooms on the orlop deck forward, insulated with granulated cork and damp-proof paper, with a casing of white pine boards, and cooled by the circulation of cold brine. The chambers have been fully provided with conveniences for stowing different kinds of goods likely to be carried. The machinery for cooling this cargo space is located on the shelter deck at the starboard side forward, and is also in duplicate, and driven by an electric motor. A notable feature of the machine installations is that each one is placed in an insulated room, so as to be accessible without any lagging or insulation having to be removed.

THE WINDMILL AND THE STORAGE BATTERY

Although, for any purpose requiring a more or less continuous supply of power, the wind is a wholly unsuitable source of energy, there are, nevertheless, many cases in which it can be utilized with advantage. Even if it has to be supplemented by a stand-by such as an oil engine, and worked in conjunction with a storage battery (which is generally an indispensable adjunct), wind-power may prove a source of economy. A few results derived from a series of experiments which has been carried on for some years by the Danish Government may, therefore, be of interest.

The velocities of the wind which are practically utilized lie between 10 and 50 feet per second, and the motor must be so constructed as to adapt itself automatically to all conditions, including storms. It has been found that a motor with only four wings is the best, and that if the surface of the wings in square feet is S, the velocity of the wind V in feet per second, and the output in horsepower is W, then $W = S\ V^3 \div 456{,}000$. Thus, for a surface of 100 square feet, with velocities of 10, 20, 30 and 40 feet per second, the power available is 0.22, 1.8, 6 and 14 horsepower respectively. At the experimental station of Askow, with a petrol-motor as standy-by and a storage battery, an installation of 450 incandescent lamps has been successfully run for two years, at a fair profit, even after allowing for interest and sinking fund charges on a 25-year basis.

COMPRESSED AIR ON THE BELMONT TUNNEL WORK

The various tunnel and subway undertakings, which are to so vastly increase the transit facilities of Greater New York, are quite different from each other in the conditions and means of construction, and each has imposed special engineering problems to be solved. Not the least interesting was the work on the Belmont tunnel, now completed and likely to be the first in actual and established service.

This tunnel and subway is over three miles long, extending from Park avenue and Forty-second street, Manhattan, to Jackson avenue and Fourth street, Long Island City, and will afford easy and quick transit between the boroughs of Queens and Manhattan, connecting with the Interborough system of subways near the Grand Central station. The first shift was started in July, 1905, and work has been rushed continuously and with tremendous vigor night and day until its recent completion. This tunnel consists of two tubes running parallel, each for a single track. Part of the tubes are horseshoe shaped, while under the river they are circular and built of sectional cast-iron rings. The builders of this tunnel, The Degnon Engineering and Construction Company, had an advantage as to time of construction, in that their tunnels could be driven from four headings instead of two, or, in the case of the Cortlandt street tunnel, from a single heading.

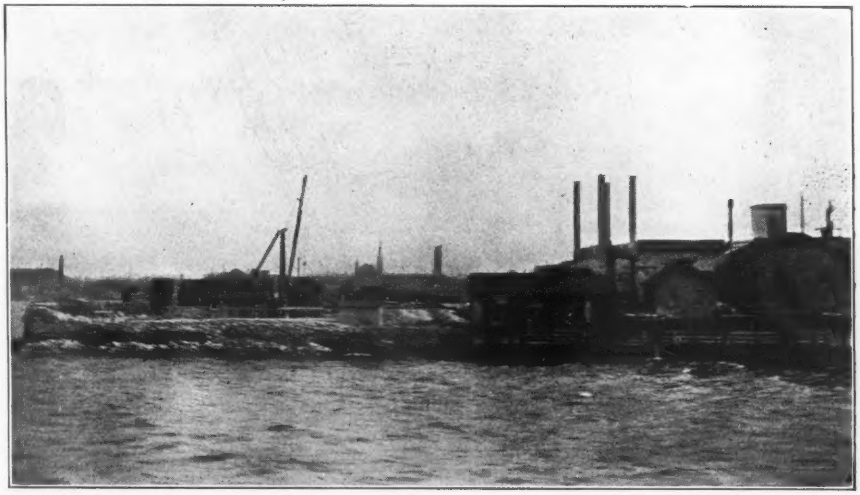


FIG. I. WORKS ON MAN-O'-WAR'S REEF.

FORTY-SECOND STREET AND EAST RIVER PLANT.

For driving the tunnel from its western end and for the subway westward through Forty-second street there were two separate installations, resulting from certain business arrangements. The plant of the O'Rourke Engineering Company, sold to the Degnon Company, comprised: one Rand cross compound Corliss two-stage air compressor with steam cylinders 24 and 40 by 48 inch stroke and air cylinders 39 and 24 inch; free air capacity, 4,147 cu. ft. per min., and one Ingersoll cross compound Corliss two-stage compressor, with steam cylinders 22 and 40 by 42 inch stroke, and air cylinders 38 and 24 inch; free air capacity, 3,937 cu. ft. per min.

The Degnon Contracting Company's own plant at the same point comprised three Ingersoll cross compound steam, duplex air, class "H" compressors, with steam cylinders 15 and 28 by 16 inch stroke, and air cylinders 20¼ inch diameter, for a maximum air pressure of 50 lbs.; free air capacity, 6,540 cu. ft. per min. There was also one Ingersoll cross compound steam, two-stage air, class HC compressor, with steam cylinders and stroke the same as above, but with air cylinders 25¼ and 16¼ inch diameter for 100 pounds air pressure; free air capacity, 1,704 cu. ft. per min.

MAN-O'-WAR'S REEF PLANT.

The most interesting, in some respects, of all the New York tunnel plants was that installed by the Degnon Contracting Company upon Man-o'-War's Reef in the middle of the East River, opposite Forty-second street. The existence of this reef suggested the sinking of two shafts there, giving four additional working faces for the two tunnels. The first thing to be done was to get standing room, as the original area was entirely insufficient. At first a single straight line Ingersoll compressor, with a portable boiler, was placed, and the sinking of the two shafts was begun, the material from the shafts being used for filling upon and around the reef until a sufficient working area was secured. The complete plant as finally installed had not a foot of space to spare. Fig. 1 is a snapshot of the exterior of the plant taken from a passing boat. The compressor room, the interior of which is shown in Fig. 2, extends to the water's edge on two sides, with only a small space on the New York side, while to the north enough land was made to provide for the moving of dirt cars to scows on either side.

The compressors used here comprised: first, one Ingersoll-Sergeant straight line, class "A," 24 inch diameter steam and 26¼ inch diame-

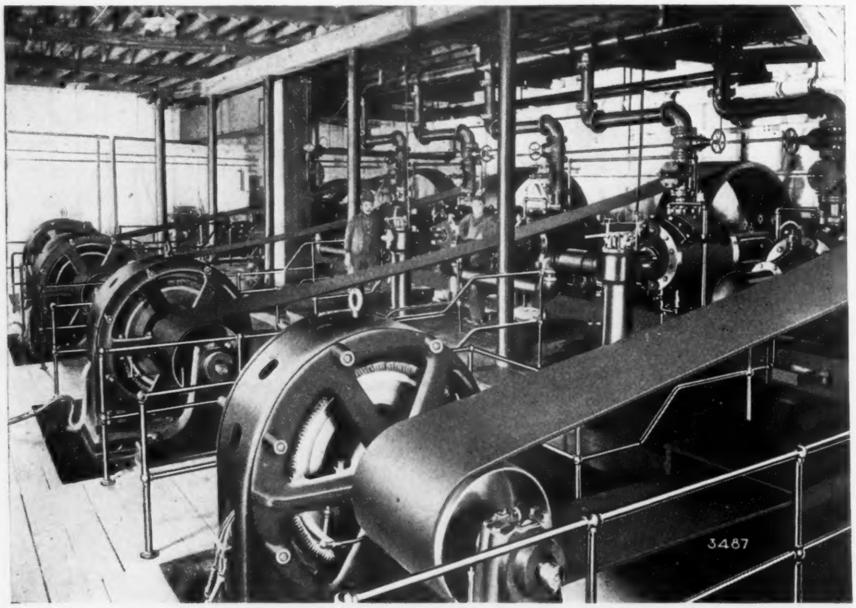


FIG. 2. ELECTRIC DRIVEN AIR COMPRESSOR, MAN-O-WAR'S REEF.

ter air by 30 inch stroke; free air capacity, 1,843 cu. ft. per min. This is the most distant compressor in the half-tone, Fig. 2, which chiefly shows the four electric driven machines. Three of these were duplex, class "J," Ingersoll, belted compressors, with air cylinders 20¼ inch diameter by 16 inch stroke; aggregate free air capacity, 6,540 cu. ft. per min. The fourth electric driven machine was a two-stage compressor with air cylinders 25¼ and 16¼ inch diameter by 16 inch stroke; free air capacity, 1,704 cu. ft. per min., this compressor delivering the air at 100 lbs., while the maximum pressure for the other three was 50 lbs.

These compressors were all run at constant speed, the air delivery being regulated by choking controllers on the intake. There was another straight line, steam driven compressor at the eastern end of the line and not included in the half-tone. The current for the electric drive was taken from a cable connecting with the Manhattan lines of the Interborough Company. The elevators in the two shafts also were electric driven from the same source. Locomotive boilers supplied the steam required for the straight line machines, the feed water being piped from Manhattan.

While this plant, on account of its location and its forbidding accompanying conditions, might have been regarded as more or less an emergency plant, it must not be thought to have been necessarily or actually a wasteful one. The electrically driven machines in this case, taking their current from a service in which the highest possible economies are attained, and having motors adapted to their work, delivered the air at a lower cost than that of the straight line, steam driven machines, notwithstanding that the latter represent still widely prevalent practice.

LONG ISLAND CITY PLANT.

Fig. 3 shows the interior of the power house of this plant. There were in service here two Ingersoll cross compound steam, two-stage air, class "H" compressors, with steam cylinders 15 and 28 by 16 inch stroke, and air cylinders 25¼ and 16¼, designed for 100 pounds air pressure; free air capacity, 3,408 cu. ft. per min. There were also two Ingersoll class "A" straight line compressors, 24 and 26¼ by 30 inch stroke; free air capacity, 3,686 cu. ft. per min., and one Ingersoll class "A" compressor, 24 and 24¼ by 30 inch stroke; free air capacity, 1,570 cu. ft. per min. These three compressors were for low-pressure air. Heine boilers were used.

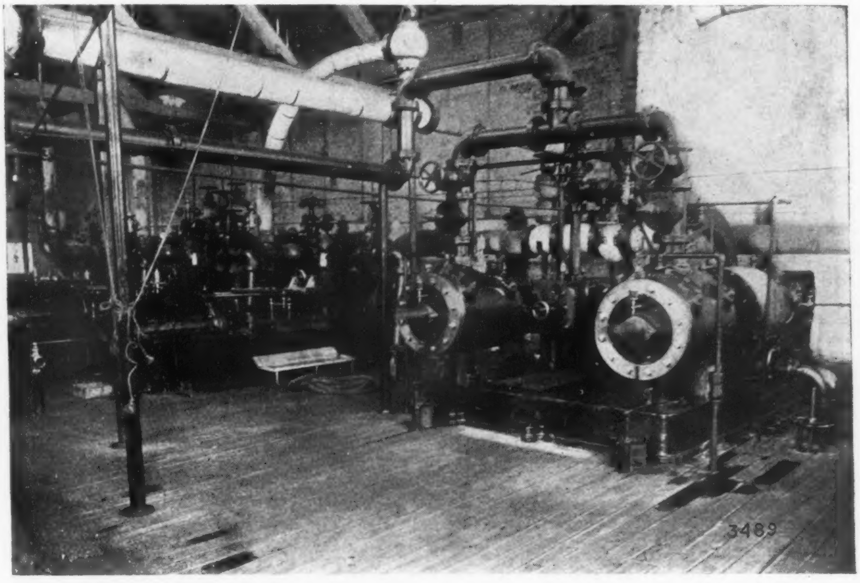


FIG. 3. AIR COMPRESSOR, LONG ISLAND CITY.

PUMPING ARRANGEMENTS.

While the pneumatic pressure maintained in the tunnels until completion was always equal to or somewhat in excess of the hydrostatic

pressure due to the submergence, there was a constant accumulation in the machines and workings of water, which was taken care of by air operated pumps. While the air pressure would be in excess at the top of the shield it might still be insufficient at the bottom and here the water would work in. This water was collected in temporary sumps in the air locks, and from there was forced out by the air pressure through the pipes to the various pumping stations situated along the line of construction. There was also a constant seeping through the joints where the calking had not been completed, the sumps for this water being situated where the grade was the lowest and where the pumps were located, pumping the water to the surface or directly into the river, or, for the land sections of the tunnels, into sewers connecting with the river.

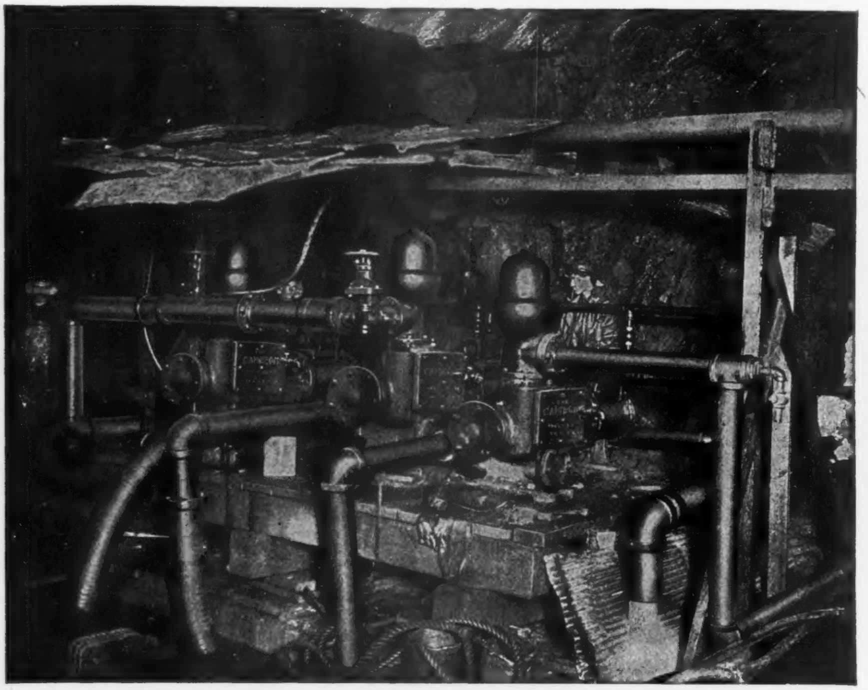


FIG. 4. PUMPS IN CHAMBER BETWEEN TUNNELS.

In several places the segments or wall plates were removed and the rock or other material forming the 8-foot partition between the two tubes was cut away, to provide sump chambers (see Fig. 4), and allowing room for the pumps. Where the pumps were situated alongside the tunnel walls and in the workings, no extra room was required for their installation (see Fig. 5), as these pumps were all of the Cameron type, with their well-known characteristics and lack of protuberant parts. These pumps have no outside valve gear, and moving levers to be deranged or broken are entirely absent. They were reliable in cases of sudden flooding and would work just as well when submerged to any depth. In cases of accident or emergency they could also be run up to double their normal capacity.

A unique and simple device was attached to the pumps to keep the exhaust compressed air from freezing and choking the passages. A small pipe was connected from the water discharge pipe to the exhaust openings of the air operated cylinder, and through it a 3/8-inch nozzle discharged constantly when the pump was running. This not only prevented freezing, but also had the effect of a muffler on the exhaust, which otherwise would have been deafening to the workers. These pumps, as was stated, were driven by compressed air, as were also the drills and the hoisting and other machinery employed.

EXPERIENCE WITH HIGH PRESSURE GAS MAINS*

By Sherwood Grover.

High pressure gas distribution, although not very old as applied to artificial gas, is no longer an experiment. When we say high pressure we mean over two pounds per square inch. There is a point beyond which, under given conditions of cost for power, materials, labor, etc., it will not pay to raise the pressure, but instead it is time to increase the diameter of the pipe, or in case of a system already installed, to lay another pipe.

High pressure systems are of two kinds. One type in which the high pressure mains are simply feeders in the form of arteries running through a district, with regulators connected here and there to boost up pressure at weak points in the low pressure distributing mains, or they may be in the form of a loop entirely circling a town and feeding in at the dead ends. The other type is where the entire system is high pressure, varying in degree, with regulators reducing the feeding main pressure of 20 pounds or more to a distributing main pressure of 2 to 5 pounds, and this in turn reduced by regulators on each house service. The writer does not favor the second type of installation, although there are conditions under which it works very well, preferring rather low pressure on all distributing mains, not to exceed 12-inch water column, with no high pressure on service pipes. This method allows using a small and practically uniform size of pipe for distribution mains in given districts, and is specially adapted to suburban tracts, where consumers are wide apart, and main extensions do not pay high returns un investment. It is surprising how many consumers with gas bills ranging from $10 to $25 per month can be supplied by a 2-inch pipe carrying a pressure of 10-inch water column.

A high pressure system can be for convenience considered as consisting of three dif-

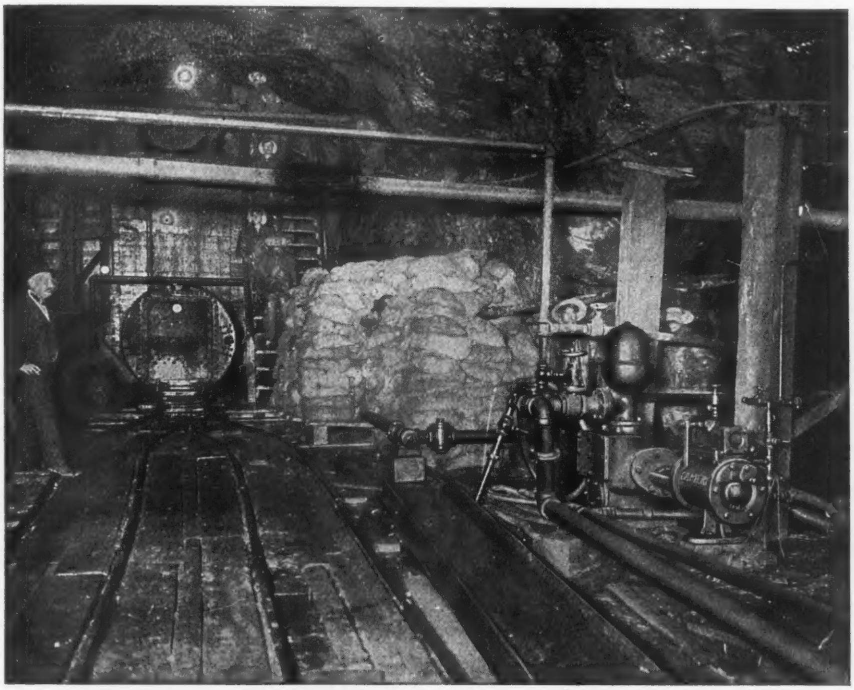


FIG. 5. PUMPS IN TUNNEL WORKINGS.

*Condensed from The Journal of Electricity, Power and Gas.

ferent parts, namely, the compression plant, the storage plant and the feeding mains.

THE COMPRESSOR PLANT.

This includes the compressors, their motive power and piping system. There is considerable opportunity for difference of opinion as to motive power, type and size of units employed, and arrangement. In case electricity is used, it is necessary to have either gas engine or steam engine auxiliary to insure against interrupted service, or else the storage plant must be of sufficient capacity to bridge over any delay which may occur.

The most efficient compressors should be used, but there are several little points, such as unloading devices, automatic or otherwise, which have more or less merit, depending on the size of the installation. An automatic unloader is very handy in a small installation, but the writer questions the economy of it in a large installation. All automatic unloaders are virtually by-passes, and by-passing compressed gas means excessive temperature of the compressor, and of the gas being compressed. Unloaders of the pattern used on compressors with Corliss valves, by which the machine can be operated at one-quarter, one-half, three-quarters or full load, are very useful. They must, however, be used with judgment, and wear on the compressor be equalized by changing sides when running at part load, so that each part of the machine has the same total number hours work.

The size of units, of course, depends upon the peak load, unless you are depending on the storage plant to carry you over. Our experience in California has, however, taught us that a unit approximately equal in capacity to the peak hourly sent out is none too large, and as it is, of course, necessary to have duplicate apparatus, it is well to have the units of varying capacity, so that by running different units during the day it can be so arranged that they are running at full load, and hence at best economy, most of the time.

STORAGE PLANT.

This consists of a battery of compression tanks, arranged on a suitable foundation, together with the system of piping and regulators connecting them to the distributing mains.

A standard size and type of tank has been adopted by our company, which was determined by economy and ease of handling and railroad transportation, together with least cost per cubic feet stored. This size is six feet in diameter by thirty feet in length, with dished heads. It has one manhole fitted with cover and yoke, one 2-inch reinforced tapped hole, which serves as both inlet and outlet, and one 1-inch reinforced tapped hole, to be used for drip pipe.

These tanks are placed in a row on the foundation, the number depending upon the amount of ground which can be used to best advantage. Other rows may from time to time be added on top of the first, making this installation a flexible one, which can be increased each year at a comparatively small cost, to meet the demands of a growing town. One tank, which we call the low pressure tank, differs from the rest in that it is a distributing tank and not a storage tank, and although it is equipped with a manhole and drip connection, like the storage tanks, it also has extra connections, to which are attached the regulators supplying the different feeding mains of the town.

In large installations it has been found most satisfactory to carry 20 pounds or under on the feeding mains, and hence the main compression units are built for this pressure only. As it is necessary to use 100 pounds pressure (not less than 80 pounds) on our storage tanks, in order to get capacity, it, therefore, follows we must have a compressor capable of compressing to 100 pounds. This unit, on account of the nature of its work, can have a very small capacity in comparison to the other machines of the installation, its use being simply to keep the storage tanks full.

The general arrangement of the compression and storage plant is as follows: The discharge from the 20-pound compressors is carried by a single line of pipe to the 20-pound tank, a branch being taken for suction to the small 100-pound compressor, so that it may take gas either at 20 pounds, or at holder pressure, as the case may be. The discharge from the 100-pound compressor is carried by a single line of pipe to the storage tanks, a 2-inch connection with valve being made to each tank. This same header is continued to the 20-pound tank and is connected to it through a regulator and by-pass. This regulator is set to maintain a pressure less than 20 pounds, say, for example, 15 pounds, then as long as there is 20 pounds pressure on the distributing tank, this regulator is shut; but if for any reason

the pressure drops, then this regulator comes into action and maintains the pressure at 15 pounds, as long as there is anything in excess of this in the storage tanks, or the small compressor is able to keep it up. The various feeding mains of the city are taken directly from the 20-pound tank, with a separate regulator on each, so that any pressure under 20 pounds can be carried on any main independent of the others.

In installing a complete plant of this nature, there are many practical points to which attention must be given to avoid trouble. To begin with, the compression tanks must be handled with care, to avoid subjecting them to unequal strains, which may cause the seams to leak.

After considerable experience with valves it has been found that nothing but extra heavy ammonia valves can be relied upon, and even these at times give trouble. An hydraulic test on a valve or stop cock is absolutely worthless if the fitting is to be used for high pressure gas.

A high pressure feeding main is subject to some of the physical laws which govern the design of a blast pipe supplying a number of sets of water gas apparatus; at the same time it is under some of the physical laws governing steam pipe design.

It naturally follows that all sharp turns should be avoided, using instead, easy curves and long sweeps. It is even well to substitute Y fittings in place of crosses or tees, where branches are taken from the main feeders.

In laying the line, care must be taken to properly anchor and brace all curves or bends. The gyrations of a garden hose, if left to itself with a good head of water on it, will serve to illustrate what will happen if this precaution is neglected.

The regulators are placed in manholes built in the street. They are either brick or concrete, and each regulator has an inlet and outlet and a by-pass valve. The use of two regulators in parallel is advocated, and, I believe, in use in some locations. We have found in this climate that one extra regulator of each size on hand is a good plan. As the regulators are inspected at regular intervals, trouble can be anticipated and the regulator removed to the repair shop, where proper adjustment can be made while the extra one takes its place. During the change the by-pass is operated.

The matter of drips has caused considerable trouble, but principally in systems where the entire installation is high pressure, or where the feeders are small. A device composed of fittings has been used in some cases, which makes the gas turn at a sharp angle to precipitate its moisture. This works very well on high pressure distribution mains of small installations, but it is not practical in a feeder at all. At first it was deemed sufficient to merely tap the main and blow out the condensation, with its own pressure. Experience, however, has shown that this does not always give satisfaction, and it was found necessary to go back to the low pressure gas practice and design a drip pot with an opening the full size of the pipe, which can be inserted in the line by means of flange-coupling adapting pieces. If you stop to consider that there is a time of minimum consumption during the twenty-four hours, when the gas in the mains is almost at rest, the velocity being practically nothing, and that this occurs when the temperature is lowest, and hence best for precipitation of moisture, it is apparent that if these drip pots are placed at the low points they will catch the condensation; then it is an easy matter to blow it out with pressure.

COMPRESSED AIR IN BLAST FURNACES

The most voluminous use of compressed air in any single industry is in the blast furnace. Prof. Bradley Stoughton of Columbia University in a description of a typical American blast furnace says:

The air for smelting is driven into the furnace by blowing engines up to 2,500 horsepower each, and capable of compressing 50,000 to 65,000 cubic feet (4,875 pounds) of free air per minute to a pressure of 15 to 30 pounds per square inch, which is about what one furnace requires. It actually requires about four to five tons of air for each ton of iron produced in the furnace. After leaving the engines and before coming to the furnace the air is heated to a temperature of 800 to 1,200° F. by being made to pass through the hot-blast stoves.

[The horsepower mentioned would be only sufficient for the compression of the smaller volume to the lower pressure. For compressing the larger volume to the higher pressure double the above horsepower would be required. Ed. C. A.]

CLEANING STEELWORK BY SAND BLAST AND PAINTING BY COMPRESSED AIR

By De Witt C. Webb.

At the U. S. Naval Station, Key West, Fla., are two large steel coal sheds whose vertical side walls are composed of ¼-inch steel plates, and are from 16 to 20 feet high. The action of heat and impurities in the coal, combined with that of the large quantities of salt water used for extinguishing spontaneous combustion fires, rapidly corrodes the interior steelwork and necessitates its thorough cleaning and painting every time the sheds are emptied.

Shortly after the writer was detailed to this station his attention was attracted to this subject, and he concluded that the use of a portable sand blast cleaning and spray painting outfit would be very advantageous in point of efficiency and time as well as cost. This idea meeting with the approval of the Bureau of Yards and Docks, the following outfit was purchased at a cost of $2,090, delivered at the Naval Station:

1 horizontal gasoline engine, about 20 hp.
1 air compressor, capacity about 90 ft. of free air per min. compressed to a pressure of 30 lbs. per sq. in. in one stage, belt connected to engine.
1 rotary circulating pump, belt connected to engine.
1 Galvanized steel water tank.
1 air receiver, 18 × 54 ins.

(The above apparatus was all mounted on a steel framed wagon with wooden housing.)

2 sand blast machines, capacity 2 cu. ft. of sand each.
2 paint spraying machines, one a hand machine of ⅔-gal. capacity for one operator, the other of 10 gals. capacity for two operators.
100 lin. ft. of sand blast hose.
200 lin. ft. of pneumatic hose for sand blast machines.
400 lin. ft. of pneumatic hose for painting machines.
100 lin. ft. of air and paint hose for painting machines.
4 khaki helmets, with mica-covered openings for the eyes.
200 lin. ft. of 2-in. galvanized iron pipe.

Previously to the delivery of this material, shed "A" had been emptied of coal and the work of cleaning the inside surface of the wall plates was begun by hand in the usual manner. About 7,000 square feet out of a total of 9,000 were thus cleaned at a cost of slightly over 4 cents per square foot. On the arrival of the sand blast outfit the hand work was stopped and after a short preliminary trial the machine cleaning was started. The work proceeded rather slowly until the men became accustomed to it, yet the 2,000 square feet of previously untouched surface was thoroughly cleaned and the 7,000 square feet of hand cleaning was all gone over and much improved at a total cost for labor of $97.68 and for gasoline of $16.15. The force consisted of the following:

	Per day.
1 engine tender	$3.04
1 helper (in charge of the work and tending machines)	2.24
2 laborers on machines, at $1.76 each	3.52
1 laborer drying sand, filling machines, etc.	1.76
Total	$10.56

From 10 to 15 gallons of gasoline were required per day of 8 hours (costing 19 cents per gallon here).

For the painting the coal tar paint originated by Civil Engineer A. C. Cunningham, U. S. N., was used (see *Eng. News*, July 12, 1906). This paint was prepared with the following proportions (by volume): Coal tar, 4 parts; kerosene oil, 1; Portland cement, 1.

The Portland cement was first well stirred into the kerosene oil, forming a creamy mixture; this mixture was then carefully stirred into the coal tar. It was freshly mixed as needed and kept well stirred. The cost of this paint at Key West is about 15 cents per gallon. It was found not to be so well suited to the pneumatic spraying machine as oil paint, but worked very well; though, of course, the machine used considerably more than hand work. In all, on this shed, 64½ gallons of paint were required for 9,000 square feet, or about 1 gallon to 140 square feet. The force used in painting was the same as in cleaning, with the addition of a laborer, who followed up the painters with a long-handled brush and spread the paint uniformly. The cost of painting this shed was: For labor, $28.16; for gasoline, $3.80.

On shed "B" a total area of 12,500 square feet was cleaned and painted. This steelwork was covered with a scale nearly ⅛-inch thick

and was deeply pitted. The scale and rust was very tough, and extremely hard to remove. On this work it was found economical to keep men ahead of the sand blast with sledges, loosening and shaking off as much of the scale as possible. The labor cost of the whole work on this shed (cleaning and painting) was $460, including the cost of moving, setting up and removing. Gasoline cost $81. A total of 86 gallons of coal tar paint was used, covering about 145 square feet per gallon. Total cost of labor, fuel and paint, $553.90, or 4.4 cents per square foot. It is impossible to separate the cost of cleaning and painting on this work, as only small areas were painted at one time, the painting being done by one operator, the other working the sand blast. This was done in order to expose the cleaned steel to the atmosphere for as short a time as possible.

A fine silica sand was used, that being the only kind available except coral sand, which was tried, but found to be too soft. A coarser sand would probably have been more effective. The sand was all saved, dried, and re-used several times. About ½ cubic yard of fresh sand was required daily. The sand must be kept perfectly dry for this purpose, and there are patented sand driers manufactured. Very good results were obtained on this work, however, by the use of a sheet of boiler plate set up on bricks with a wood fire underneath.

No claims are made of extreme economy in the above work. The extremely thick and tough scale to be removed, the high fuel and labor cost of compressing air simply for this work, and (probably) the lack of the best kind of sand for the purpose, combined to make the work expensive. With these drawbacks it was, however, considerably cheaper than hand work, and what is more important, the cleaning was much more effective and thorough than could possibly have been done by hand.—*Engineering News.*

COMPRESSED AIR DISTRIBUTION

A correspondent writes to *South African Mines*, Johannesburg, as follows:

"It is obvious that no matter what the air pressure is at the compressor house, or at the different stations in the Rand mines, the last machine, or the last few machines, taking air from the air pipe on any level must receive less pressure than those near the air column in the shaft. To explain: The first machine to receive air from the connection at each station will, obviously, obtain the greatest pressure, the second a little less, the third less still, and so on; the fourteenth or fifteenth is always badly served. From reference, I can tell you that, in most instances, the first machine has far too great a pressure, and often one dare not turn on the full force, but must work at three-quarter. This is regulated by the machine tap. While at the other end, say the fifteenth machine, it would be good work to drill two 6-in. holes in eight hours. My suggestion is that the 3-in. or 4-in. pipes in the level be tapped near the center of the working area, and a pipe run *back* towards the main connection. Then the air pressure would be evenly distributed, and as development proceeds the tapping of the main could be changed from time to time."

This seems to suggest a state of affairs entirely unknown in American practice and which might be thought to be impossible even in South Africa. Unless the pipe line was extremely small and the distances great, with all the drills working constantly, no such experience as above indicated could occur. In American mining practice every drill on the line gets very nearly the same pressure, and if this pressure is sufficient for the first it should not be very deficient for the last, while if the pressure was not sufficient all the drills would suffer. The impression is that insufficient compressor capacity is the familiar condition in South Africa, and that few drills there have sufficient air in both pressure and volume.

STEAM CONSUMPTION IN AIR COMPRESSORS

The accompanying tables have been prepared by Mr. O. S. Shantz, M. E., Detroit, Mich., and are an entirely new and important contribution to engineering data. They show the weight of steam required to compress 100 cubic feet of free air to the various gage pressures listed either in single or in two-stage compression. They are based on the various steam consumptions per indicated horsepower per hour shown at the head of each column. The computations are based on adiabatic compression in all the cylinders with a mechanical efficiency in the compressor of 90 per cent.

The mode of using these tables will be as

Pounds Steam Consumption per I. H. P. per hour..........	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21
Air Pressure, Gauge 20	1.36	1.42	1.47	1.53	1.58	1.65	1.70	1.75	1.82	1.87	1.92	1.98	2.04	2.09	2.15	2.21	2.26	2.32	2.38
" " 30	1.84	1.92	1.99	2.07	2.14	2.23	2.30	2.37	2.45	2.53	2.60	2.68	2.76	2.83	2.92	2.99	3.06	3.14	3.22
" " 40	2.26	2.36	2.45	2.54	2.64	2.73	2.83	2.92	3.02	3.11	3.20	3.30	3.39	3.48	3.58	3.68	3.77	3.87	3.96
" " 50	2.62	2.74	2.84	2.95	3.06	3.17	3.28	3.38	3.50	3.61	3.71	3.82	3.93	4.04	4.16	4.26	4.36	4.49	4.59
" " 60	2.92	3.05	3.17	3.29	3.41	3.54	3.66	3.77	3.90	4.02	4.14	4.26	4.38	4.50	4.64	4.75	4.85	5.00	5.11
" " 70	3.22	3.36	3.50	3.63	3.76	3.90	4.02	4.16	4.30	4.43	4.56	4.70	4.83	4.96	5.11	5.24	5.36	5.50	5.64
" " 80	3.50	3.65	3.80	3.94	4.08	4.24	4.37	4.52	4.67	4.81	4.96	5.11	5.25	5.40	5.55	5.69	5.84	5.99	6.12
" " 90	3.72	3.88	4.06	4.19	4.34	4.50	4.65	4.80	4.96	5.11	5.26	5.43	5.58	5.73	5.90	6.05	6.20	6.36	6.50
" " 100	3.96	4.13	4.30	4.46	4.61	4.79	4.95	5.11	5.29	5.45	5.61	5.78	5.95	6.10	6.28	6.45	6.60	6.77	6.93
" " 110	4.18	4.36	4.54	4.71	4.87	5.06	5.22	5.40	5.58	5.75	5.92	6.10	6.26	6.45	6.63	6.80	6.96	7.15	7.31
" " 120	4.38	4.57	4.75	4.94	5.11	5.30	5.47	5.65	5.85	6.03	6.20	6.40	6.57	6.75	6.95	7.12	7.30	7.50	7.67

Pounds Steam Consumption per I. H. P. per hour..........	21½	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Air Pressure, Gauge 20	2.44	2.49	2.60	2.72	2.83	2.94	3.06	3.17	3.28	3.40	3.50	3.61	3.74	3.85	3.97	4.08	4.18	4.30	4.42	4.54
" " 30	3.30	3.37	3.52	3.68	3.82	3.98	4.14	4.29	4.44	4.60	4.75	4.90	5.06	5.20	5.36	5.51	5.66	5.81	5.97	6.12
" " 40	4.06	4.15	4.34	4.52	4.70	4.90	5.08	5.26	5.46	5.65	5.85	6.03	6.22	6.40	6.60	6.78	6.95	7.14	7.35	7.50
" " 50	4.71	4.80	5.02	5.25	5.45	5.68	5.90	6.10	6.33	6.55	6.76	7.00	7.20	7.42	7.65	8.86	8.05	8.27	8.51	8.71
" " 60	5.25	5.36	5.60	5.85	6.08	6.32	6.56	6.80	7.05	7.30	7.55	7.80	8.03	8.27	8.52	8.76	8.99	9.22	9.50	9.71
" " 70	5.78	5.90	6.16	6.45	6.70	6.97	7.25	7.50	7.77	8.05	8.32	8.60	8.85	9.12	9.40	9.66	9.91	10.16	10.45	10.70
" " 80	6.29	6.42	6.70	7.00	7.29	7.59	7.86	8.15	8.48	8.75	9.05	9.34	9.62	9.92	10.20	10.50	10.75	11.05	11.36	11.61
" " 90	6.68	6.82	7.14	7.45	7.75	8.05	8.36	8.66	8.98	9.30	9.60	9.94	10.21	10.54	10.85	11.15	11.41	11.74	12.09	12.35
" " 100	7.10	7.25	7.59	7.92	8.25	8.58	8.90	9.22	9.57	9.90	10.20	10.56	10.90	11.20	11.55	11.88	12.16	12.50	12.85	13.15
" " 110	7.50	7.66	8.00	8.36	8.70	9.05	9.40	9.75	10.10	10.45	10.76	11.15	11.50	11.84	12.20	12.52	12.84	13.20	13.55	13.90
" " 120	7.86	8.04	8.40	8.76	9.11	9.50	9.85	10.20	10.58	10.95	11.30	11.66	12.05	12.40	12.76	13.13	13.45	13.82	14.21	14.55

STEAM CONSUMPTION OF AIR COMPRESSORS.

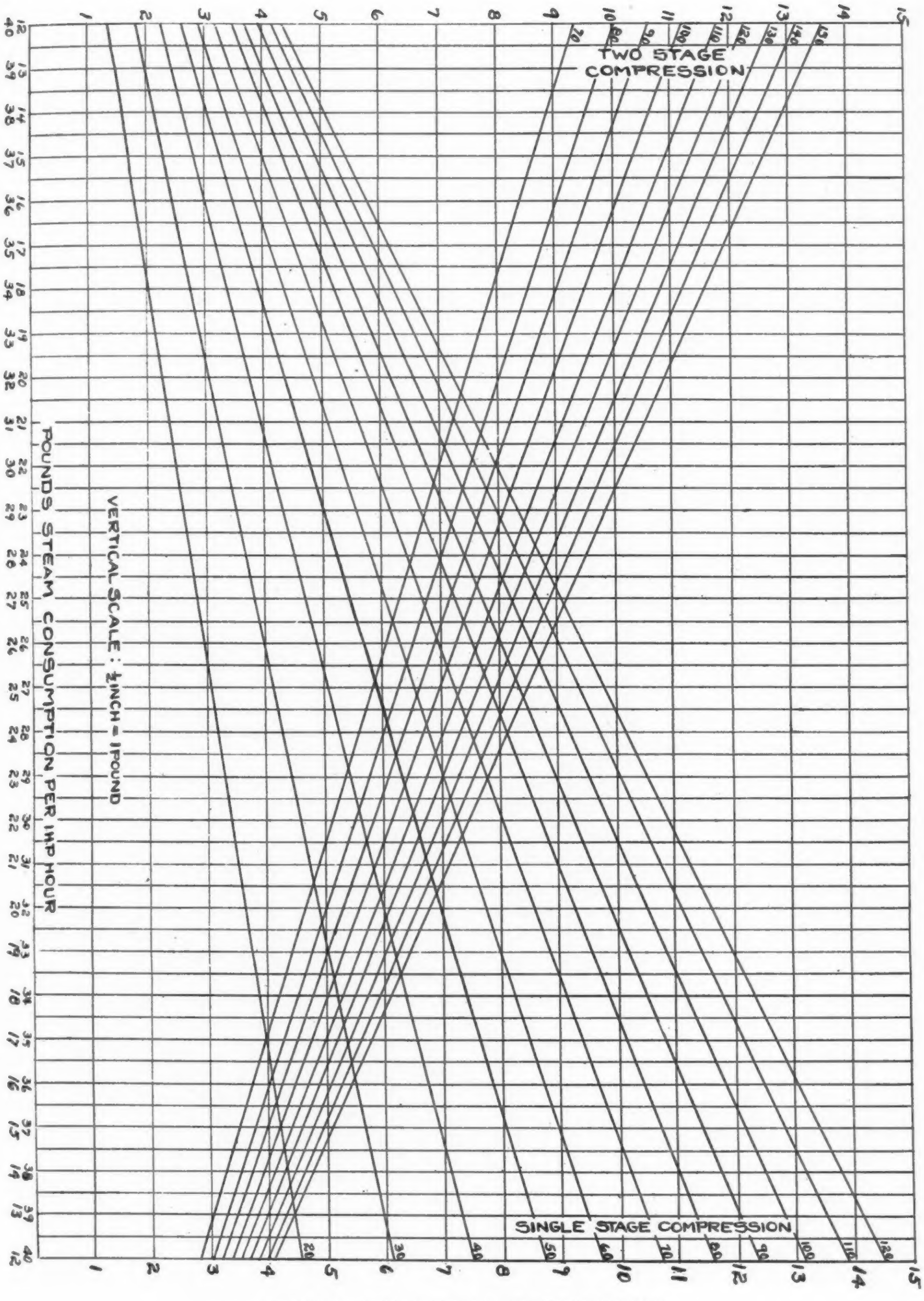
SINGLE STAGE COMPRESSION.

Pounds Steam Consumption per I. H. P. per hour..........	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21
Air Pressure, Gauge 70	2.82	2.93	3.06	3.17	3.25	3.41	3.52	3.63	3.76	3.87	3.78	4.11	4.23	4.34	4.46	4.58	4.69	4.81	4.93
" " 80	3.01	3.13	3.27	3.39	3.51	3.64	3.77	3.89	4.03	4.15	4.26	4.40	4.52	4.64	4.78	4.90	5.02	5.15	5.27
" " 90	3.19	3.33	3.46	3.58	3.72	3.86	3.99	4.12	4.26	4.39	4.52	4.66	4.79	4.91	5.06	5.18	5.32	5.46	5.58
" " 100	3.37	3.51	3.65	3.79	3.93	4.07	4.21	4.35	4.50	4.63	4.77	4.92	5.05	5.18	5.34	5.47	5.61	5.76	5.90
" " 110	3.54	3.70	3.84	3.95	4.14	4.29	4.43	4.57	4.74	4.88	5.02	5.17	5.32	5.46	5.63	5.76	5.91	6.06	6.21
" " 120	3.69	3.85	4.00	4.15	4.30	4.46	4.62	4.76	4.93	5.08	5.22	5.39	5.54	5.69	5.86	6.00	6.15	6.32	6.46
" " 130	3.83	3.99	4.15	4.30	4.46	4.63	4.79	4.95	5.11	5.26	5.42	5.59	5.75	5.90	6.07	6.22	6.38	6.55	6.70
" " 140	3.96	4.13	4.30	4.45	4.62	4.79	4.95	5.11	5.29	5.45	5.60	5.79	5.94	6.10	6.28	6.45	6.60	6.77	6.93
" " 150	4.10	4.26	4.45	4.60	4.76	4.95	5.11	4.28	5.46	5.62	5.80	5.98	5.14	6.30	6.49	6.65	6.81	7.00	7.16

Pounds Steam Consumption per I. H. P. per hour..........	21½	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Air Pressure, Gauge 70	5.05	5.16	5.39	5.63	5.85	6.10	6.33	6.56	6.80	7.04	7.26	7.50	7.74	7.96	8.20	8.45	8.65	8.90	9.15	9.35
" " 80	5.41	5.53	5.77	6.03	6.27	6.53	6.78	7.03	7.27	7.53	7.78	8.03	8.29	8.53	8.78	9.05	9.25	9.53	9.80	10.01
" " 90	5.73	5.85	6.10	6.38	6.65	6.91	7.17	7.44	7.70	7.98	8.24	8.50	8.77	9.03	9.31	9.57	9.81	10.05	10.35	10.60
" " 100	6.05	6.19	6.45	6.74	7.01	7.30	7.57	7.85	8.15	8.42	8.70	8.99	9.26	9.55	9.85	10.10	10.35	10.63	10.95	11.20
" " 110	6.37	6.51	6.80	7.10	7.40	7.70	7.96	8.27	8.58	8.86	9.16	9.46	9.75	10.05	10.35	10.64	10.90	11.20	11.51	11.80
" " 120	6.64	6.78	7.08	7.38	7.69	8.00	8.31	8.61	8.92	9.24	9.53	9.85	10.15	10.46	10.75	11.05	11.35	11.65	12.00	12.27
" " 130	6.88	7.03	7.34	7.66	7.97	8.30	9.61	8.92	9.25	9.57	9.90	10.20	10.52	10.84	11.15	11.48	11.76	12.10	12.42	12.72
" " 140	7.11	7.26	7.59	7.92	8.25	8.60	8.90	9.23	9.56	9.90	10.20	10.56	10.90	11.21	11.55	11.88	12.18	12.50	12.85	13.15
" " 150	7.35	7.50	7.84	8.17	8.51	8.86	9.20	9.55	9.90	10.20	10.55	10.90	11.25	11.60	11.91	12.26	12.58	12.90	13.28	13.60

STEAM CONSUMPTION OF AIR COMPRESSORS.

TWO-STAGE COMPRESSION.



STEAM CONSUMPTION OF AIR COMPRESSORS.

follows: A steam consumption per indicated horsepower hour is assumed based upon an understanding of the type of steam end of the compressor, the steam pressure, cut off, vacuum if condensing, etc. Under this assumed figure on the line opposite the required air pressure, will be found the pounds of steam consumed per 100 cubic feet of free air compressed. The accuracy of these tables in practice depends upon the correct assumption of the indicated horsepower steam consumption. Where this cannot be exactly determined the tables can at best be considered as only an approximation.

The tables will, however, be found very useful for quickly making comparisons as to the amount of fuel consumed by the various types of air compressers, thus showing approximately the expected yearly saving by the use of, for instance, a compound as compared with a simple machine. For example, a straight line compressor with a steam consumption of 30 pounds, single-stage compression to 100 pounds gage, requires 9.9 pounds of steam per 100 cubic feet of free air compressed. A compressor with duplex steam cylinders, at the same steam consumption, but with compound or two-stage air cylinders, requires 8.42 pounds of steam. A compressor with compound steam cylinders, non-condensing, with a 26 pound steam rating and compound air cylinders requires 7.3 pounds of steam, while a high-class Corliss compressor using steam at high pressure with compound steam cylinders running condensing with a water rate of 17 pounds (including the condenser) and with compound air cylinders, requires 4.77 pounds of steam, or one-half as much as in the first example.

The average man, however, thinks in pounds of coal rather than in pounds of steam. For the purpose of comparison it will usually be better, therefore, to reduce deductions to terms of pounds of coal burned per hour or per day by dividing the steam consumption by 7, since a fair evaporation for average conditions is 7 pounds of water per pound of coal burned. This states the case upon a dollars and cents basis when the price of coal is known.

H. V. Conrad.

[The diagram, page 4671, embodies everything contained in the tables and requires practically no explanation. The steam consumption for single stage compression is represented by the oblique lines which rise from the lower left hand side, and the lines for two-stage compression start from the lower right hand side. The numbering at the bottom of the table is therefore reversed for convenience of reading from either end. For general purposes the diagram may be found more convenient than and practically as reliable as the tables.—Ed. C. A.]

THE "WESTFALIA" RESCUE APPARATUS

A modified form of the well-known "Shamrock" type of rescue apparatus has been introduced by the *Armaturen und Maschinenfabrik* Westfalia, of Gelsenkirchen. As shown by the diagram, the two steel oxygen cylinders, each charged with 120 litres (4.23 cubic feet) of oxygen, are carried in an inverted position on the shoulders, an arrangement enabling the pressure gage, reducing valve, safety valve and injector to be placed near the store of oxygen in such a manner that the injector, assisted by the oxygen issuing from the jet, forces the aspirated circulating air, and any accompanying water, from above downward. The air and oxygen are conveyed through the flexible pipe A into the inhaling pipe and attached mouth pipe B, the nozzle of which is divided into two chambers by a horizontal partition, so that the exhaled air is conveyed through the lower chamber and pipe C leading to the regenerator.

This latter consists of a slightly arched metal case, shaped so as to fit across the chest of the wearer, and fitted with ten superimposed sheets of wire gauze. A sheet of strong absorbent paper is inserted halfway up, and both the top and bottom halves are filled with granulated caustic soda and potash. The re-purified air is led through the pipe D to the back of the wearer, and, being cooled there by passing through a metal pipe, bent like a frame around the oxygen flasks, is aspirated by the injector, and being enriched with oxygen, resumes its circulating course. Both air tubes communicate with the corresponding halves of a bag behind the regenerator—an arrangement affording a reservoir of air for emergencies and facilitating respiration. The shut-off valve for the two cylinders is accessible to the wearer; and the lower extremity of the exhaled air pipe is fitted with a detachable cap for catching saliva (which is often secreted copiously, especially by unskilled wearers), and a blow-off

valve for relieving excessive pressure of air or oxygen. A whistle may also be provided in the pipe leading to the reducing valve, and arranged to blow as soon as the internal pressure falls to 30 atmospheres, thus indicating to the wearer that the supply will only last about another half-hour, and that it is therefore time to retire. When the pressure falls below 25 at-

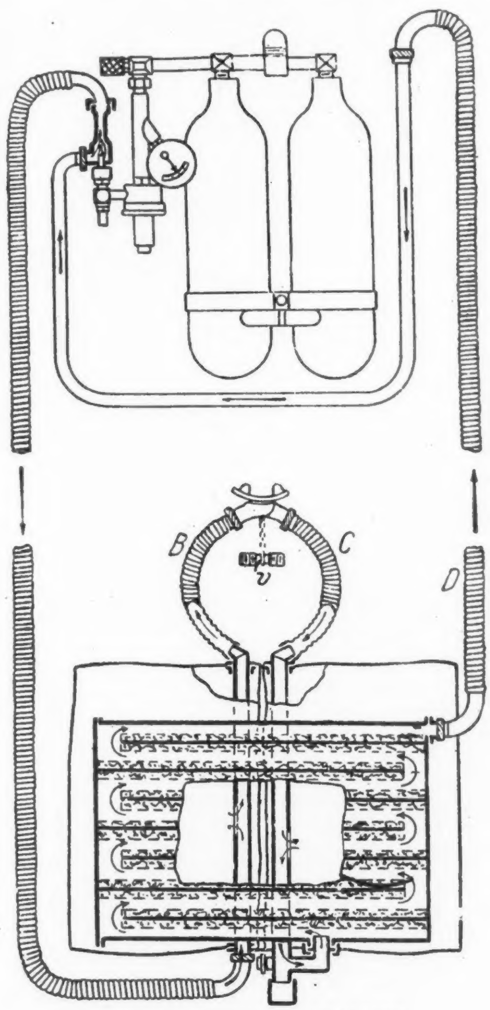


DIAGRAM OF RESCUE APPARATUS.

mospheres the whistle is closed by the action of a spring. The total weight of the apparatus, ready for use, including leather knapsack for covering the oxygen bottles, is 39 to 40 pounds.

From trials made for periods of two hours each, the wearers being engaged in work, it appears that the absorption of carbonic acid is quite sufficient in view of the high percentage of oxygen in the air of the apparatus, and the wearers experienced no particular inconvenience in performing their tasks. The percentage of CO_2 in the inhaled air ranged between 0.22 and 1.66 per cent in all the trials except one (when it was 2.4 per cent) at the end of two hours. The volume of air circulating in the apparatus was 55 to 79 litres (2 to 2¾ cubic feet) per minute, the pressure of the injector being equal to 8 to 11 centimetres (3¼ to 4¼ inches) water gage.

THE GAGE FROZEN UP.

PIPING AN AIR GAGE

Jim Peters learned his trade at Clark Bros.' engine works, and continued to work there after his apprenticeship was served. He was considered a good man, capable of doing almost any job, steady, sober and industrious, but he had one fault that sometimes led him into blunders; he did not always find out the "reason why." He had learned almost everything he knew about the trade by experience, and had accepted many shop practices without fully knowing why they were followed. One of his blunders—the last—was piping an air gage, and what he learned from that ex-

perience was valuable, for after that day he made it a rule never to do anything without knowing *why* he did it.

Ben Clark, the junior member of the firm, was the superintendent and general foreman of the machine shop. When an air compressor plant was put in to operate pneumatic hammers and riveters in the boiler shop, the "super" put Jim on the job, which included the erection of the air compressor in the engine room, lines of piping to the shops, and a big receiver in the boiler shop. An air gage on the receiver was called for by the specifications, and Jim duly put it up in the way that he had learned was the correct thing for steam boilers, that is, with a siphon-shaped pipe connection.

The job was completed late in November, and all went well for several weeks, until one frosty morning in December the foreman of the boiler shop called the super's attention to the fact that the air gage on the drum showed not a pound pressure although the pneumatic hammers were making a merry din. One glance at the pipe connection told the super what was the matter. Going into the machine shop he walked up to Jim and said:

"Did you ever stop to think?"

"W-w-what's the matter now?" said Jim, growing red in the face, for he "smelled a rat," as the boys say.

"Why do you connect a *steam* gage with a siphon pipe?"

"I-I-I don't know," confessed Jim.

"Just what I thought," said the super, "for if you did you wouldn't have been such a fool as to put one on an air gage, especially in a cold boiler shop. Have you worked all these years here without learning that the siphon loop is simply a trap for condensation to protect the works from the hot steam? Pretty thing, though, to put on an air drum to freeze up over night. Looks nice, but you'd better straighten it."

Jim is nearly through with his correspondence course now, and he is growing to think that perhaps the air gage job was a good thing after all.—*Machinery.*

LIQUID AIR AN EXPLOSIVE IN COAL MINING

Some account of the practical use of liquid air in coal mining is given in a recent issue of *Montan Zeitung.* It was first used in combination with other materials, but is now used alone, its explosive power depending upon its property of turning suddenly into vapor at an elevated temperature. If the vessel in which the liquid air is contained is sufficiently tight, very high expansive powers are attained. For this reason it is stored in vessels having a small opening. This property of the liquid air makes it necessary to place the cartridge in place in the rock before it is loaded. In English mines the cartridges are made of thick phosphor bronze, the loading being calculated so that the pressure reaches 5.6 kilograms per square centimeter (80 pounds per square inch). The explosion takes place in six or eight minutes after loading and about 30 tons of coal are broken by one shot. The coal falls in blocks about 60 centimeters (2 feet) in circumference. A heavier loading of the cartridge causes the coal to be broken into powder.

A UNIQUE CHIMNEY FAILURE

Mr. Worcester R. Warner, of the Warner & Swasey Company, Cleveland, recently addressed a letter to the smoke inspector of that city, in which he said:

"I write to ask your suggestion in regard to a chimney which we built two years ago, which we have been using for the past year. I believe the general impression is that chimneys are used for the purpose of carrying away smoke, but this new one that we have been using for the past year does not seem to fill the bill in any sense, for it not only does not carry away smoke, but the bricks at the top even are nearly as clean and free from grime as when it was erected. Should you happen to be out in this neighborhood I would be glad to have you call and give us any suggestions which your experience may lead you to offer looking toward the proper utilization of this chimney. The furnace under it is developing at least 350 horse-power, and the coal we are using is the cheapest kind of slack. We have, however, thus far been unable to make any smoke. Can you tell us what is the matter?"

The cause of the failure of this chimney to emit the customary smoke is in the fact that the grate surface and the firebox space are much larger than usual, and that there is no crowding of the fire. The same conditions would result in similar failures in other cases, and the chimneys, useless as smoke conveyors, might be looked up to as monuments to perpetuate the fame of good engineering.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896.

W. L. SAUNDERS, - - - - - - - - Editor
FRANK RICHARDS, - - - - - Managing Editor
GARDNER D. HISCOX, - - - - Special Contributor
L. I. WIGHTMAN, - - - - Business Manager
H. L. KEELY, - - - - Circulation Manager

PUBLISHED BY THE

COMPRESSED AIR MAGAZINE COMPANY

EASTON, PA.

New York Office, Bowling Green Building.
London Office, 114 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year, Single copies, 10 cents.

Those who fail to receive papers promptly will please notify us at once.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed, air.

Entered as second-class matter at the Easton, Pa. Post Office.

Vol. XII. DECEMBER, 1907. No. 10

CONTENTS.

For the convenience and satisfaction of all concerned, it has been determined to close Volume XII with the present issue, and hereafter the volume will begin and end with the year. We are glad to be able to say that COMPRESSED AIR is prospering and growing, and with the coöperation of subscribers and advertisers we may hope to do much more for each other than ever before.

THE SHINING OF THE SUN

The sun shines everlastingly upon the United States and gives us constant and rapid growth. Our 85 millions of people increase by 2 millions a year and our wealth grows still faster. In 1890 the total value of our farm products was $2,466,000,000, in 1900 it was $4,717,000,000, while this year the aggregate is $7,000,000,000, and the value of our manufactured and mining products is two and a half times this, or $18,000,000,000. These are ready money values. The money should normally be spent over and over again, much of the spending following almost immediately, since other crops and other annual masses of products will be crowding upon us. Both the handling of the material products and of the monies which represent them bring special embarrassments by their very magnitude. Our transportation facilities do not grow fast enough nor our stocks of handy money either. We are tumbling over ourselves and we can't get out of our own way and as we stumble our headway is checked.

Another aggravation seems to have little connection with the above as to cause, but cooperates beautifully with the rest for the promotion of disaster. Worst of all for us seems to be the fact that the sun shines not only, as we are assured, upon the unjust as well as upon the just, but also upon the pessimist, and it would seem that the more generous is the sun with his rays of beneficence the more rankly does the pessimist grow. When things are at their best the pessimist is at his worst. When things are about as bad as they can be his occupation is gone. When we are flat on our backs there is no way to look but upward. The sick man may soon be continually assuring his friends that he is certainly better than he was before he began to improve.

It is easy enough to blame Wall Street and

the inelasticity of our currency. Wall Street could not have its opportunity to keep on selling things down and down except for those who can be discouraged or scared into letting their holdings go. Our currency should have more elasticity, we are told, but when morbid impulse gets full swing and runs on the banks begin and every pessimist grabs and locks up every dollar he can reach, the elasticity must be phenomenal not to reach the point of rupture.

There is no time and no place where the pessimist cannot do more harm than good. "I told you so," when calamity comes, is only a masquerade of wisdom. He who "Never dispaired of the Republic" was the ideal statesman, and he who is sure that the sun never ceases to shine upon us is the stable and winning man of business.

THE PROBLEM OF THE AIR COMPRESSOR

Correct practice in industrial lines is of slow development. Never are the best means or the best methods first thought of or adopted, and the later ways of doing things generally show improvement and advantage over all which have preceded them.

There is the lubrication of machinery, for instance. We may suppose that it was known almost from the first that oil is good to stop the squeaking of a wheelbarrow, and it soon came to be understood, no doubt, that oil will also make things run easier, and so the hand oil can came into existence to be used when thought necessary, and often under compulsion to relieve ears or muscles. To-day the need of lubrication is recognized as constant, and continually running plants are provided with a continuous circulation of the lubricant.

The air compressor—speaking here chiefly of the steam-driven machine—is a curious and pertinent illustration of this habit of first adopting the crude and the inefficient, and of the later gradual adaptation of the machine to its complicated and exacting duties. The rock drill came into existence, and it at once demanded a supply of compressed air for driving tunnels, sinking shafts and for general mining work. Its demands were so urgent that practically anything which would go and keep going, maintaining the required air supply, was at first accepted. Not only were the earlier styles of machines crude and wasteful, but they were surprisingly long retained, and only quite recently has the demand for economy and complete adaptability in air compressors, as in other machinery, decidedly asserted itself.

The steam-driven air compressor has to satisfy many more conditions than at first glance may appear, and the designing of such a machine is a much more complicated task than that of any steam engine or any water pump. The range of opportunities, either of waste or of saving, is decidedly greater in the air compressor than in the steam pump or the stationary steam engine. Even in the steam end of the machine—looking at that alone—the requirements are quite different, for while the stationary engine must maintain a constant speed under a variable load, the compressor has a practically constant load per stroke, while the total amount of work required in any given time may vary widely, thus necessitating, as the most obvious solution, a continually varying speed.

When the steam and the air cylinders are in a straight line, the pressure in the one being directly applied to the overcoming of the resistance in the other, we have in every stroke the continually diminishing pressure in the steam cylinder opposed to the continuously increasing resistance in the air cylinder, so that while the total pressure in the steam cylinder may be quite sufficient for the work required of it, the distribution of it is unfortunate, and somewhere in the machine must be provided a means of storing the surplus of force at the beginning to be given out again at the end of the stroke. In duplex machines the two sides help each other over these hard places, so that if the fly-wheel is depended upon to be the equalizer and distributor, a lighter wheel is required for the two sides of the machine than would be required for either side alone.—*Cassier's Magazine.*

CORRESPONDENCE

COMPRESSED AIR IN THE UNIVERSITY OF MICHIGAN

Editor Compressed Air:

I noticed an article some time ago in your magazine stating that the subject of Compressed Air had been taught as a distinct subject in but one university in this country, and I wish to correct the mis-statement. Com-

pressed Air has been taught at this university as a separate subject for ten years. At first it treated Compressed Air and Refrigeration in one class, but these have now been separated and we devote two hours per week for half a year to recitations on Compressed Air. The class starts with low-pressure types of compressors, then high-pressure compressors are taken up and two or three stage compression, and in the class we also teach on the theory of centrifugal fans and pressure blowers.

JOHN R. ALLEN,
Junior Professor of Mechanical Engineering.

"DIFFERENT VACUUMS"

Editor Compressed Air:

Allow me to protest against the definition of "vacuum" of Tecumseh Swift in your November issue. He says the "actual vacuums we know about are only partial differences and deficiencies as compared with fullness or excess of pressure elsewhere." The last six words are the ones to which I object.

They should be changed to the words "atmospheric pressure." If the examples of exhausting from high pressure into external atmosphere, or from rock drills at high pressure into a pressure of 25 pounds gauge in a tunnel, can be considered exhausting into a vacuum, then the exhaust of the high-pressure cylinder of a triple expansion engine into the first intermediate receiver might also be called exhausting into a vacuum. The fact is that the word "vacuum" is never used by good engineering writers in the sense in which Mr. Swift uses it in this article. We have enough troubles with the English language now, without having it further corrupted by expanding the meanings of words in common use to such an extent as Mr. Swift would expand them.

WM. KENT,
Dean and Professor of Mechanical Engineering, Syracuse University.

PNEUMATIC MICROMETRICS

Editor Compressed Air:

We all of us have some respect for the atmosphere, and we generally understand in a way that we couldn't get along very well without it! yet many of us have an idea that it does its work in a rough kind of way, notwithstanding that it gets there every time. The fact is that the atmosphere is one of the instruments by whose aid nature does some of its finest work, and that relatively to Earth as a whole its functions are adjusted with micrometric precision.

I suppose that my favorite plaything—in my mind—is an eight-inch terrestrial globe, and I am particular about the size of it, as that enables me to do my thinking to scale, a very necessary condition if my thinking is to be of any account. Earth is understood to be about eight thousand miles in diameter, and on our eight-inch globe, therefore, a thousandth of an inch will represent a mile. This at once makes things on Earth's surface look very small, and the heighths and the depths which make our scenery for globe trotters to laud and magnify become too minute to detect.

If there was a fellow big enough to hold Earth in his hand like an orange its surface would appear to him smoother and more highly polished than glass. If we suppose our eight-inch globe to be as highly polished as possible all over its surface and if we paste upon it a bit of paper a thousandth of an inch thick, the thinnest tissue paper we can get, that will of course be a mile high, and it will represent the range of altitudes within which 95 per cent. or more of the human race live and move and have their being. Dwellers on plains and prairies who know nothing higher than a two-story or a three-story house may be assumed to keep all their goings up and goings down within a vertical range of fifty feet, one-hundredth of the thickness of our bit of tissue paper, one one-hundred-thousandth of an inch (.00001). I as a New Yorker have a vaster range of altitude. I do my coming and going on Broadway. I am doing this writing 150 feet above the sidewalk and I take my lunch in a restaurant 300 feet above the sidewalk, so that in my daily life I can boast of a vertical range of at least .00006 inch on my eight-inch globe.

In this connection atmospheric air, "free air," may do some micrometer work for us. I have a pocket aneroid barometer, which, as everybody knows, is simply an air pressure gauge, that is another of my habitual playthings—this also mostly in my mind—and I have tried it in the elevators of some tall buildings. I find that this handy instrument will show a difference in the pressure of the air with a change of elevation of 25 feet, corresponding to .005 of the thickness of the sheet of tissue paper or to .000005 inch on the diameter of our eight-inch globe. There are

fine instruments in use by engineers which will show a difference of elevation of 5 feet, which would be .001 of the thickness of our bit of tissue paper, or .000001 inch, which would be .000000125 of the diameter. The difference of air pressure per square inch for a difference of 5 feet in altitude would be about .0025 lbs. This makes it look after all as if the air did some pretty fine work.

While the actual pressure of the air in any given locality fluctuates constantly, so that a barometer is practically never at rest, the mean pressure is maintained with wonderful constancy. This pressure depends ultimately upon the total quantity of air in existence, which by its weight presses upon the lower stratum with which only we are in touch. Notwithstanding that both animal and vegetable life are constantly absorbing the constituents of the air, these are constantly removed or replaced, so that both the total volume and the weight of the air are maintained and the proportions of its constituents show no change.

A bit of the page of an ordinary book, say .005 inch thick, would represent on our little globe the highest land of Earth, and a much greater range of altitudes than it is ever possible for man to occupy, while the thickness of tissue paper first assumed represents the very greatest depths beneath the surface of Earth of which we have any knowledge by actual contact or observation. The air is our jailor and must ever keep us from breaking our bounds either upward or downward. When we keep our normal level our jailor is our best friend and benefactor, but we cannot escape our aerial environment in any direction.

TECUMSEH SWIFT.

QUESTIONS AND ANSWERS

T. F. H., Cumberland, B. C.—*Q.:* How is the horse-power of an air compressor computed? For instance, we have an air compressor, two-stage, with low-pressure cylinder, 32″ diameter; high-pressure, 20″; stroke, 30″. This machine is catalogued at 347 and 390 horse-power at 80 and 100 pounds air pressure, respectively. I would like to know how this is worked out.

A.: In the above enumeration one absolutely essential particular is omitted: the number of revolutions or double strokes per minute. The actual horse-power of a running compressor can only be computed from a full set of indicator cards. In the present case we made a rough computation of the power required in single-stage compressors, or as if all the work of compression was done in the first or low-pressure cylinder. From Table II., page 29, of Richards' Compressed Air we find that the mean effective pressure for compressing to 80 lbs. is 36.6 lbs. Assuming the speed to have been 80 revolutions, or 400 feet, per minute, we then have the following statement: $32^2 \times 7854 \times 36.6 \times 400 \div 33000 = 356.79$. This is the theoretical horse-power required, and if we add 10 per cent. it will be near the actual. Then $356.79 + 35.68 = 392.47$. If we deduct from this 12 per cent. for the probable saving of power by two-stage compression, we have: $392.47 - 47.09 = 345.38$, which is very near the figures given above by our correspondent. For compressing to 100 lbs., single-stage, the mean effective pressure is 41.6 lbs. Then we have as before: $32^2 \times 7854 \times 41.6 \times 400 \div 33000 = 405.50$, which with 10 per cent. added gives us $405.50 + 40.55 = 446.05$, and deducting 12 per cent. as before we have $446.05 - 53.52 = 392.57$, which also is near the figures of our correspondent. The deduction for saving by two-stage compression should of course be greater for compression to 100 lbs. than to 80 lbs. It is to be remembered that the saving of power in two-stage compression is by no means the only, and often not even the chief consideration to recommend two-stage compression. The avoidance of the high and often dangerous temperatures is not only important, but also imperative if the compressor is to run with safety and at sufficient speed to be efficient.

C. T. B., St. Louis.—*Q.:* The letter of Mr. Tecumseh Swift in your October issue, in which he suggested that the air pressure at a depth of a dozen miles below the surface of the earth would be over 100 lbs. rather surprised me and I tried to do a little figuring about it. I dug up an empirical formula for computing air pressure at different altitudes which was published in COMPRESSED AIR several years ago. The following is the formula:

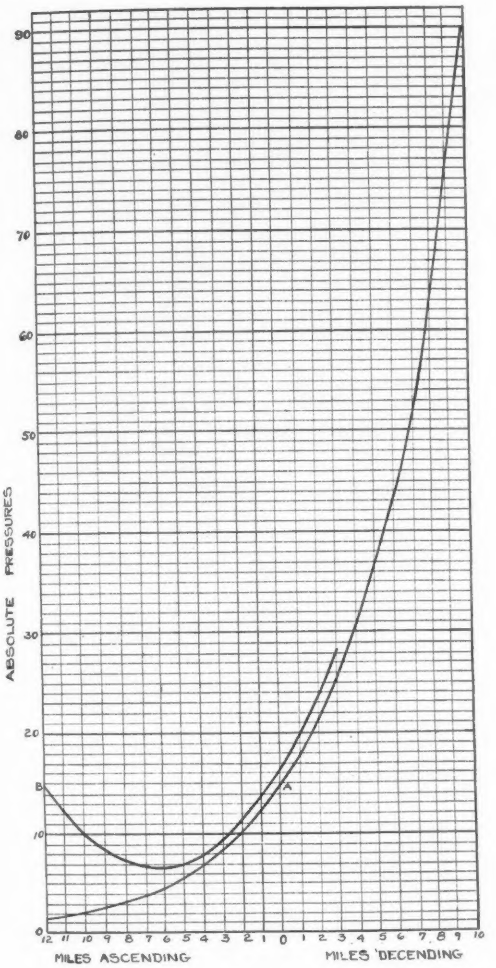
$$A = 14.72 - \frac{57{,}000\,N - N^2}{100{,}000{,}000}$$

A is the absolute pressure at any elevation and N is the elevation in feet.

The writer said: "This formula gives results in some cases varying about one-sixth of one per cent. from certain published tables, but it has the advantage that when plotted it

gives a *perfect* curve, which no table that I have seen will do."

Thus assured, I started my figuring with perfect confidence, beginning first with altitudes above sea level, and the following are the results as far as I went:



Absolute Air Pressures at Different Altitudes by a Freak Formula.

Sea level	14.72	40,000	7.92
5,000 feet	12.12	45,000	9.32
10,000 "	10.02	50,000	11.22
15,000 "	8.42	55,000	13.62
20,000 "	7.32	60,000	16.52
25,000 "	6.72	65,000	19.92
30,000 "	6.62	70,000	24.72
35,000 "	7.02	75,000	28.22

Here the pressure, instead of constantly decreasing, actually began to increase above 30,000 feet altitude, but, as the writer said, a perfectly smooth curve resulted, as I have plotted on the scrap of section paper herewith (see line commencing at B on the diagram). With such luck in figuring up hill I did not try going below sea level, as the result would of course be similar, only reversed. Can you suggest a more satisfactory formula?

A.: We suggest another empirical formula or rule: Deduct successively 17 per cent. from the absolute pressure for each mile of ascent, or add 20 per cent. for each mile of descent. The following results will be obtained:

ABSOLUTE AIR PRESSURES.

Ascending.		*Descending.*	
Sea level	14.7	Sea level	14.7
1 mile	12.2	1 mile	17.64
2 "	10.13	2 "	21.17
3 "	8.41	3 "	25.43
4 "	6.98	4 "	30.43
5 "	5.8	5 "	36.45
6 "	4.98	6 "	43.66
7 "	4.14	7 "	52.33
8 "	3.44	8 "	62.77
9 "	2.86	9 "	75.26
10 "	2.38	10 "	90.26
11 "	1.98	11 "	108.34
12 "	1.65	12 "	129.95

The diagram shows that these figures also make a perfect curve. The sea level start of the curve is at A, reading down to the left for the diminishing pressures in ascending and upward to the right for the increasing pressure is descending. The shorter curve shows the results from the formula referred to by our correspondent. The sea level start for this curve is at B.

L. I., York, Eng.—*Q.:* I want an engine driven by compressed air to run about ten minutes at a time and to develop ¼ horse-power at 1,500 revolutions per minute. What would be dimensions of engine, capacity of receiver and what charging pump or compressor would be required?

A.: The question permits the adoption of a variety of pressures and other particulars in the solution of it. We assume here a working pressure of 50 lbs. at the motor with a cut off at one half stroke, which would give a mean effective pressure per stroke (see Richards' "Compressed Air") of 37 lbs., say 35 lbs. Then with an engine cylinder 1.25 in. diameter and 1.25 in. stroke at 1,500 revolutions per min. the horse-power developed would be:

$1.25^2 \times .7854 \times 35 \times 312.5 \div 33000 = .4068$ h. p.

The factor 312.5 is, of course, the piston speed in feet per min., which we are well aware is excessive for so small an engine. The .4 horse-power obtained, when allowance is made for friction and other losses, would not be greatly in excess of the .25 horse-power required. The air consumption per min. would be:

$1.25^2 \times .7854 \times 1.25 \times 1500 \div 1728 = 1.33$ cu. ft.

This would be 13.3 cu. ft. for 10 minutes, and if we add 50 per cent. to this for clearance, leakage, etc., which is not too much to cover all contingencies, we would require just 20 cu. ft. of air at 50 lbs., or:

$15 : 50 + 15 :: 20 : 86.66$ cu. ft. free air.

The initial receiver pressure would of course be required to be much higher than 50 lbs., the air being delivered through a pressure reducer and maintaining a constant pressure of 50 lbs. at the motor until the pressure in the receiver was down, or nearly down, to that, when it would require to be recharged. The contents of the receiver below 50 lbs. would of course not be usable and must always remain in the receiver. Say that a pressure of 210 lbs., or 15 atmospheres, was obtained in the receiver to start with, then a receiver 1.5 feet dia. and 5 feet long would be sufficient for the purpose. These being the internal dimensions, the cubic content would be:

$1.5^2 \times .7854 \times 5 = 8.8$ cu. ft.

This being filled with air at 15 atmospheres the free air represented would be $8.8 \times 15 = 132$ cu. ft. When the 86.66 cu. ft., say 90, required to run the motor 10 minutes had been discharged there would remain in the receiver $132 - 90 = 42$ cu. ft. and the pressure of this would be: $8.8 : 42 :: 15 : 71.5$, and $71.5 - 15 = 56.5$ lbs., only a little in excess of the requirements.

The capacity of the compressor for charging the receiver would depend upon the time allowed for the compression, and it is not necessary to go into any computation concerning it. In any case the power required for the compression would be considerably greater than that realized at the motor. The work of compression would increase as the pressure rose in the receiver. The free air consumption at the motor being 8.66 cu. ft. per min., the theoretical power required to compress this volume to 50 lbs. (see Richards' "Compressed Air") would be $8.66 \times .1195 = 1.03$ h. p., to which should be added at least 15 per cent. to cover all losses. This would be the power required at the beginning of the recharging of the receiver, while when the 210 lbs. terminal pressure was approached the power required would be more than double this. As a scheme of power utilization this use of air is not to be recommended. The mode of computation here adopted might have been greatly complicated by considering the temperatures of the air at the different stages, but time and space would not permit.

COMPRESSED AIR AND GRAMOPHONES IN INDIA

A lady whose friendship for COMPRESSED AIR began when she was "typist," as she modestly puts it, to a live machinery man at Kalgoorlie, Australia, but who now resides at Singapore, India, kindly sends us the following clipping from a daily of that city:

The local agents of Pathe Freres gave a trial run yesterday afternoon to the latest device in gramophones, namely one worked by compressed air. The trial, which was attended by several people interested, proved quite successful. The new system is worked by electricity. Current is turned into a small compressing machine which transmits the compressed air into the machinery of the gramophone where it establishes a far better pressure on the sapphire point than can be obtained under ordinary circumstances. The records come out much clearer and louder and there is greater steadiness. The machine will soon be on the market and is so arranged that it can be adapted to any house electric connection and will later be supplied with manual pressure. The gramophone with this machine and Pathe records, etc., is really a quite efficient substitute for a band and the music is the nearest approach to the actual music we remember to have heard. While the gramophone was in operation a series of excellent cinematograph films were run off and showed the great range of subjects this company possesses.

NEW BOOKS

The Use of the National Forests.—U. S. Department of Agriculture, Forest Service, 42 pages 5x7 inches, 7 full-page half-tones. There are, we are told in this book, 173 national forests in different States and Territories, with a total area of 148,000,000 acres, and this inter-

esting little book tells of the purposes for which these forests are reserved, the wise and enlightened methods by which they are cultivated and cared for and the beneficial results for the nation and the individual.

The Blacksmith's Guide, by J. F. Sallows.—The Technical Press, Brattleboro, Vt., 157 pages, 4½x7¼ inches, 150 or more illustrations. This neat little book is the work of a practical, successful every-day working blacksmith. It describes the various operations of the trade and the tools used, but it is specially devoted to the responsible work of tool making in all its details, with copious information concerning the heat treatment of steels, annealing, hardening and tempering. Three of the illustrations are in color, showing heat and temper scales and the artistic effects of casehardening.

Suplee's Mechanical Engineers' Reference Book is attaining the success it so well deserves. It has been thoroughly revised, and appears in a third edition with 62 pages of new matter. It contains more useful and immediately available engineering data than any other book in English. Its 400 illustrations are as useful in their way as the text.

Economy in Lubrication. By William A. Mayes, Reading, Pa., 28 pages, 5⅜x7¾ inches. Illustrated with half-tones, diagrams and charts. The purpose seems to be to argue, in whose interest does not appear, that grease is bad and oil is good for machinery. "Mailed for the asking."

TRADE PUBLICATIONS

Alundum, Norton Company, Worcester, Mass., 12 pages 3⅜x6¼ inches (nearly postal card size, but too long for enclosure in a common letter envelope).—Gives a very interesting and readable account of the production of Alundum in the electric furnace and of its various uses as an abrasive of the highest efficiency.

Simplex Concrete Pile Foundations, The Foundation Company, 115 Broadway, New York, 88 pages 6x9 inches.—This publication consists principally of excellent half-tones showing the actual employment of those concrete pile foundations under a great variety of conditions and for most responsible service.

Pneumatic Cranes and Hoists, Quincy, Manchester, Sargent Company, Chicago, New York, 36 pages 6x9 inches, numerous illustrations.—The hoists shown are of the familiar single cylinder direct lift type and various styles of cranes are shown in which they are applied. Valves, hose and various appurtenances are shown and lists of capacities, dimensions, etc., are given.

Catalogue of Steam Pumps, No. 35, A. S. Cameron Steam Pump Works, New York, 157 pages 6x9 inches, copiously illustrated. Tables and Useful Information.—These pumps normally have no exposed working parts and are built in a great variety of styles and sizes to suit all lines of service.

Handling and Storing Coal and Ore, Dodge Coal Storage Company, Philadelphia, 112 pages 6x9 inches, numerous half-tones.—The machinery under construction, installed and in use to date provides for the storage of 4,660,000 tons of coal. Many of the installations included are illustrated and briefly described in this publication. The devices employed are also treated in detail.

FREE ENGINEERING LIBRARY TO OPEN EVENINGS

The reference libraries of The American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and The American Institute of Mining Engineers, 29 West 39th street, New York, will be open evenings until nine o'clock on all week days except public holidays. These libraries, constituting practically one library of engineering, situated near the New York Library, in the new headquarters of the Engineering Societies, are available to members of the above societies, engineers, and the public generally, subject to proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies.

The receivers assure the clients of The Westinghouse Machine Company and all others interested, that there should be no occasion for apprehension because of the company's application for a receivership. This action was deliberately and thoughtfully taken as a sensible and logical measure for conserving the interests of the customers, creditors and stockholders of a solvent institution which is doing a large and profitable trade. There has not been even a momentary pause in the operations of the company, and the personnel remains the same as heretofore.

NOTES

Mr. H. B. Ayers has become General Manager of H. K. Porter Company, locomotive builders, Pittsburgh. Mr. Ayers has been for the past two years in charge of the Canadian Locomotive Works at Montreal and before that he was General Manager of the Pittsburgh Locomotive Works, so that he is experientially qualified for the position.

The air expended in the coal controversy over the Pacific fleet would keep mining machines running long enough to dig fuel enough to keep the fleet at sea long enough to lick the Japs or any other bunch until they had cried "Enough."—*Coal Trade Bulletin.*

A new pneumatic mail tube is being laid in Philadelphia for connecting Station C, Nineteenth and Oxford streets, with Station J, Nineteenth and North streets. This is the beginning of a system, the contracts for which have been let, to connect the principal substations of the city with each other and with the central station.

The unit of coinage in Mexico is the peso and not the dollar, and to speak of Mexican dollars is incorrect. The value of the peso is only about one-half that of the United States dollar, this not referring to the relative weights of the silver coins. The sign of the peso is a capital letter P with two fine horizontal lines across the upper portion.

Fruit is being "naturally dried" in California by artificial means. A continuous draft of air at a temperature of 150 degrees is passed through trays containing the fruit with results highly satisfactory. Two weeks' time is saved in the drying of prunes and their condition is said to be better with less loss of weight.

It is stated by an English writer in *Nature* that the United States government spends annually more than $13,700,000 in scientific work, exclusive of the large grants for purely educational interests. The sum spent for similar purposes by the British government is about $1,200,000. The revenue of the United States is given as $762,375,000, and that of Great Britain $719,885,000, which indicates a surprising difference in the estimates of ultimate values in two nations with interests presumably so nearly identical and whose future is to be shaped by the same agencies.

Frank Gilroy, chief engineer of the New York Central's compressed air system in Buffalo, has invented a device for tamping up ties with pneumatic tools which assures a uniform stroke. Experts are of the opinion that such a method will solve the problem of broken rails. Mr. Gilroy's invention is to be tested on the West Shore at Utica.

The device for furnishing the air is carried on a skeleton rubble car and is said to be light enough for any ordinary gang to lift from the track. Rubber hose carries the compressed air to the tools, which are operated simultaneously on opposite sides of each tie and pound away at the rate of several hundred strokes each minute.

Statistics have again been obtained with reference to the use of coal-cutting machines in the United Kingdom. In 1906 there were 333 collieries where coal-cutting machines were at work, as against 295 in the preceding year. The total number of machines employed was 1,136 (as against 946 in 1905), of which 451 were worked by electricity and 685 by compressed air; the total quantity of coal obtained in 1906 by the aid of these machines was 10,202,506 tons. This is an increase of 2,100,309 tons compared with 1905, and 4,458,462 tons compared with 1904.

Nothing could be simpler than the working of a gas engine. "You see, when the piston comes up and compresses a lump of gas a spark jumps in and touches it off and the engine gives a poke, which turns the crank shaft around. Then the piston comes back and chases out the burned gas and takes in a fresh charge as it goes back; then it comes up and the load gets a spark and the piston is blown back and the crank shaft gets another poke, just as before. Every time a spark is let in the engine gets a poke, and gives it to the crank shaft, you see. It's perfectly simple and simply perfect."—*Life.*

Three-phase electric locomotives were started to run the trains through the Simplon tunnel. These engines took up almost the entire available section of the tunnel, acting much like a projectile and pushing large volumes of air before them, with great consumption of

power and reduction of speed. Also in going from the cool outside air into the tunnel atmosphere, which is warm and moist, they become covered with a profuse condensation, so that some of the motors have given out because, it is supposed, of the moisture penetrating the insulation. Steam locomotives fitted with smoke consumers have therefore been adopted, at least for the present.

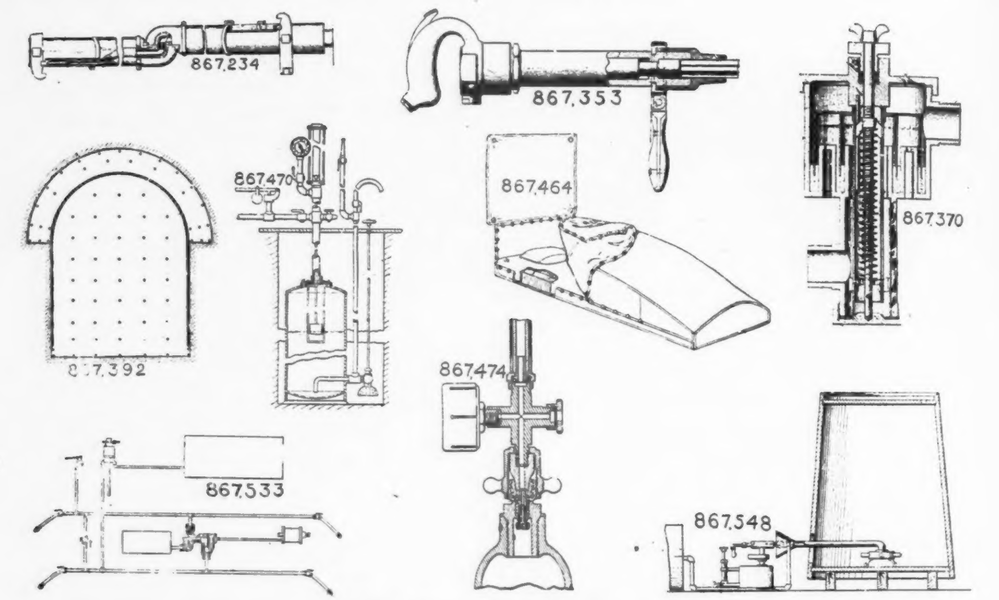
A pneumatic ammunition hoist for war vessels is under development by the U. S. Ordnance Bureau. It is believed that the new hoist will effectually prevent such accidents as the one which occurred last July on the "Georgia." Some of the members of the board which investigated that accident were of the opinion that friction on the rails carrying the ammunition car, in the type of hoist used, had ignited the charge; sparks have been observed when the rapidly moving car strikes the bend in the guide rails. The purpose of the new hoist is to prevent not only the falling of burning grains of powder, but also any such effects of friction; the carrier will travel in a heavy, seamless brass tube, preventing any possible access of sparks or burning grains to the powder delivered in the turret.

One of the largest blasts ever fired in France was discharged recently at the quartzite quarries at Cherbourg, and is said to have displaced 120,000 tons of stone. A tunnel measuring six feet wide and six feet high was driven into the face of the cliff for a distance of seventy feet, and at its end two branch tunnels, each twenty feet long, were driven to the right and left respectively. These branches ended in chambers forty feet apart and seventy feet from the face of the cliff, and measuring each ten by six by six feet. The chambers were charged with eight and a half tons of blasting powder and 280 pounds of dynamite, and the blast was fired electrically. The quartzite obtained from this quarry finds much favor in England as a road material.

The Federal Government of Switzerland has a monopoly of the alcohol supply industry of that country. Denatured or industrial alcohol is sold by the government at cost—about 25 cents per gallon. It is prohibited to mix any substance with denatured alcohol that would counteract the effect of the denaturization or change its taste or smell. There are two methods of denaturizing the alcohol—the complete and the incomplete. The complete method is applied to spirits which are to be used for heat, light and power purposes. This alcohol is fully denatured; pyridine is used as a base and the process is secret and frequently changed. Incomplete denaturization prevents the alcohol from being used as a beverage, but does not destroy its properties for special uses.

An explosive costing considerably less than dynamite, which was experimented with in the construction of the Simplon tunnel, is made by soaking meal or powdered charcoal in liquid air or liquid oxygen, the powdered carbon being first packed into a case made of stout paper and covered with an asbestos wad, through which passes a paper tube to the bottom of the cartridge. Just before firing, the liquid air is poured into the tube, and the firing is as usual by means of a fulminate cap. As the liquid air gradually evaporates, the period between filling and firing is limited to below ten minutes. A missfire is not dangerous, because at the end of half an hour the liquid has entirely disappeared and the cartridge may again be handled with safety. The use of this economical explosive had to be abandoned in the tunnel by reason of the quantities of carbon monoxide which it produced in the constricted space.

Rats are the cheapest mine scavengers there are; they are plentiful in the stopes of Bisbee and of the Comstock. The writer knows of no harm that they do underground, and, considering the great amount of good that they do, he would even advise their introduction in mines where the men eat underground. Rats are good indicators of impending caves in the stopes. When the rats leave a stope (unless it is due to some obvious cause such as the introduction into a stope of air-drills where formerly hand-drilling was used) it is time for the miners to leave also. The rats sometimes bother candles and, it is said by some, also dynamite, but this damage does not amount to much. In fact, the writer never knew of the rats bothering the candles or the dynamite at Bisbee, where the rats have plenty of chance to do so; probably they eat the candles only when very hungry. The Malthusian principle prevents an overabundance of rats at a mine.—*Mining and Scientific Press.*



PNEUMATIC PATENTS, OCTOBER 1.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

OCTOBER 1.

867,234. SAFETY-VALVE FOR AIR-BRAKE. THOMAS BEHAN, Aliquippa, Pa.

867,353. PNEUMATIC HAMMER. ALFRED J. DOUGHTY, Detroit, Mich.

867,370. PRESSURE-EQUALIZING VALVE. CHARLES W. HENSON, Chicago, Ill.

867,392. METHOD OF TUNNELING. DAVID MAXWELL, Detroit, Mich.

The herein described method of tunneling, which consists in preliminarily cutting or drilling to outline the cross-section of the tunnel, and also drilling exteriorly of such cross-section at the top of the tunnel, and subsequently dislodging and removing the material contained in the outlines area and in the exteriorly drille area; substantially as described.

867,464. PNEUMATIC SLEEPING-BAG. THOMAS ABBOTT, Reading, Mass.

867,470. PNEUMATIC WATER-ELEVATOR. JOHN E. BOURNE and ORLANDO W. STEVENS, Somerville, Ohio.

867,474. DEVICE FOR INFLATING TIRES, &c. ROBERT H. CAMPBELL, Edmonton, England.

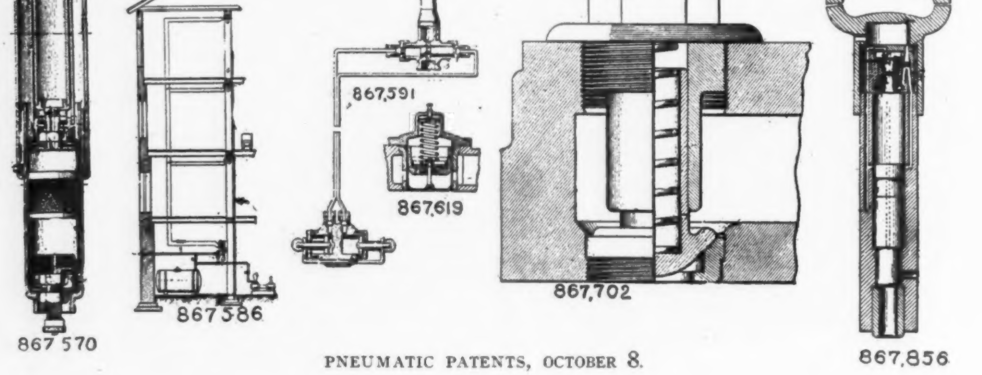
867,533. AIR-BRAKE SYSTEM. HENRY N. RANSOM, Cleveland, Ohio.

867,548. MEANS FOR DRYING THE INTERIOR OF VATS, &c. JACOB H. BECKMAN, Seattle, Wash.

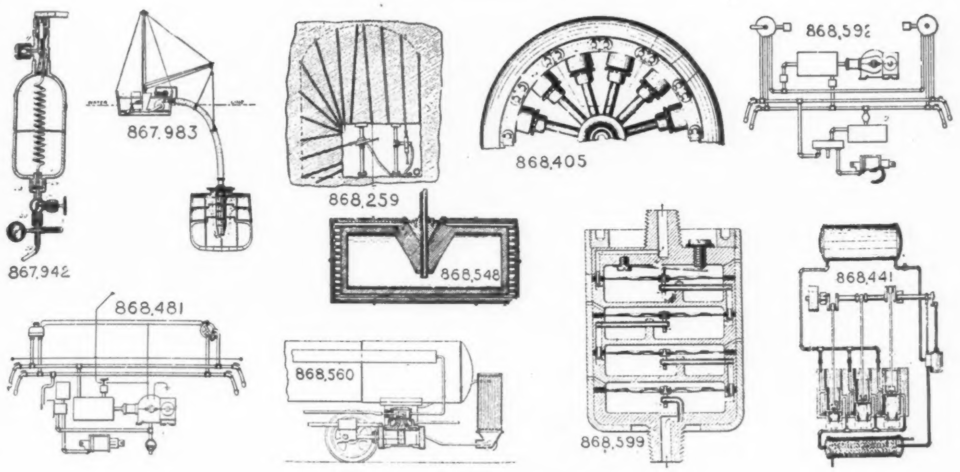
In a device for drying the interior of vats, means adapted to be arranged for movement within the vat for distributing air therein, a pipe leading from said means without the vat and having a funnel shaped mouth, means for heating the mouth of said pipe, and means for directing air under pressure into the mouth of said pipe, for the purpose specified.

OCTOBER 8.

867,570. PNEUMATIC SUSPENSION MEANS. JAMES H. CLARK, Richmond, Va.



PNEUMATIC PATENTS, OCTOBER 8.



PNEUMATIC PATENTS, OCTOBER 15.

867,586. LIQUID-DISTRIBUTING MEANS. EDWARD J. MOORE, Cleveland, Ohio.

In liquid distributing means, a liquid storage tank having compressed air connections, and a line of distributing pipe for said tank having valved outlet connections, in combination with means to relieve said tank of compressed air, and an air intake valve for said line of pipe adapted to open automatically when the pressure is relieved within said tank, whereby the liquid within the pipe is drained back into said tank.

867,591. PNEUMATIC VALVE-CONTROLLING APPARATUS FOR GAS-BURNERS. RICHARD N. OAKMAN, Brooklyn, N. Y.

867,619. SELF-ACTING VALVE FOR COMPRESSORS AND THE LIKE. FERDINAND STRAND, Schmargendorf, Germany.

867,702. DISCHARGE-VALVE FOR GAS-COMPRESSORS. ARTHUR F. CLARKE, Butler, Pa.

867,856. PNEUMATIC TOOL. EDWARD M. TOBIN, Barre, Vt.

OCTOBER 15.

867,942. COMPRESSED-FLUID CHARGING AND DISCHARGING DEVICE. GABRIEL A. BOBRICK, Los Angeles, Cal.

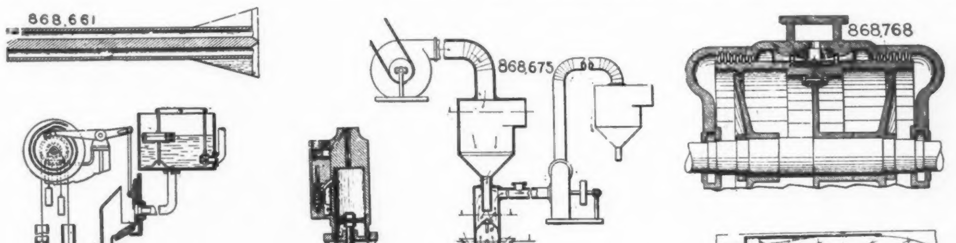
867,983. MEANS AND APPARATUS FOR RAISING SUNKEN VESSELS. SIMON LAKE, Bridgeport, Conn.

868,259. METHOD OF EXCAVATING ROCK TUNNELS. PATRICK FORD, Chicago, Ill.

The method of excavating rock tunnels comprising first constructing an under heading for the length of the tunnel and then arranging the air and the pipe lines close to the wall of the heading then throwing down the material from the roof of said tunnel into said heading and operating at either or both ends of the tunnel.

868,405. WHEEL. GEORGE F. BRANDENBURGH, Irvington, N. J.

In a wheel, the combination of a hub providing an annular chamber and means for supplying compressed air thereto, hollow spokes each inserted at one end



PNEUMATIC PATENTS, OCTOBER 22.

into the said hub in communication with the chamber thereof and being enlarged at its outer end, and hollow felly sections, one for each spoke and each provided with an arc-shaped chamber communicating with a tubular mouth having at its inner side a slideway for the enlarged end of its spoke.

868,441. COMPRESSED-AIR MOTOR. CHARLES D. JENKINS, Boston, Mass.

868,481. AIR-BRAKE SYSTEM. HENRY N. RANSOM, Albany, N. Y.

868,548. COMPRESSED-AIR TANK. WILLIAM J. GRIFFIN, Morley, Mich.

868,560. INTERHEATER FOR COMPOUND COMPRESSED-AIR ENGINES. CHARLES B. HODGES, Pittsburg, Pa.

In a compound compressed-air engine in combination with the high-pressure and low-pressure cylinders and their inlets and exhausts, of a receptacle for compressed air connected with the exhaust from the high-pressure cylinder and with the inlet to the low-pressure cylinder, and means for causing a current of air to flow over the surface of the said receptacle operative on the exhaust of air from the low-pressure cylinder, substantially as described.

868,592. AIR-BRAKE SYSTEM. CHARLES E. BARRY, Schenectady, N. Y.

868,599. PRESSURE-REDUCING VALVE. CLYDE J. COLEMAN, New York, N. Y.

OCTOBER 22.

868,661. PNEUMATIC AND OTHER DRILL. MARTIN HARDSOCG, Ottumwa, Iowa.

868,675. SCREENING COLLECTOR AND SEPARATOR. LEE LOCKWOOD, Des Moines, Iowa.

868,776. AUTOMATIC FLOW-REGULATOR FOR LIQUIDS AND GASES. JOHN H. GREGORY and WALTER W. JACKSON, Columbus, Ohio, and FREDERICK N. CONNET, Providence, R. I.

868,768. ELASTIC-FLUID TURBINE. RAYMOND N. EHRHART, Pittsburg, Pa.

868,787. ELASTIC-FLUID TURBINE. OSCAR JUNGGREN, Schenectady, N. Y.

868,868. AIR-MOTOR. PETER KIEFER, St. Louis, Mo.

868,939. PNEUMATIC PUMP. HADLEY C. REAMES, Los Angeles, Cal.

868,946. TORPEDO - PROJECTING APPARATUS FOR SUBMARINE AND SUBMERSIBLE VESSELS. HENRI SMULDERS, Schiedam, near Rotterdam, Netherlands.

869,019. FLYING-MACHINE. JOHN D. PURSELL, Chattanooga, Tenn.

869,023. PNEUMATIC BRUSH. JACOB E. SCHADLE, St. Paul, Minn.

OCTOBER 29.

869,247. COMBINED MOTOR AND HAND OPERATED ROTARY BLOWER. HENRY B. KEIPER, Lancaster, Pa.

869,262. ASPIRATOR. EDWIN PYNCHON, Chicago, Illinois.

869,278. ROCK - DRILL - FEED MECHANISM. THOMAS TURNER, Ottumwa, Iowa.

869,288. SOUND-AMPLIFIER. NATHANIEL BALDWIN, Heber, Utah.

869,337. PNEUMATIC - DESPATCH - TUBE APPARATUS. CHARLES F. STODDARD, Boston, Mass.

869,373. VALVE MECHANISM FOR AIR-COMPRESSORS. FRANK LAFFERTY, Elyria, Ohio, and WATSON SPENCE, Philadelphia, Pa.

869,453. FLUID-PRESSURE MOTOR. SPENCER OTIS, Chicago, Ill.

869,542. PNEUMATIC CLEANING DEVICE. WILLIAM J. BERGENS, Pittsburg, Pa.

869,544. REGULATING DEVICE FOR DUST-REMOVING PNEUMATIC MACHINES. JULES R. BLUM, Paris, France.

869,552. SIGNAL APPARATUS. CLARENCE W. COLEMAN, Westfield, N. J.

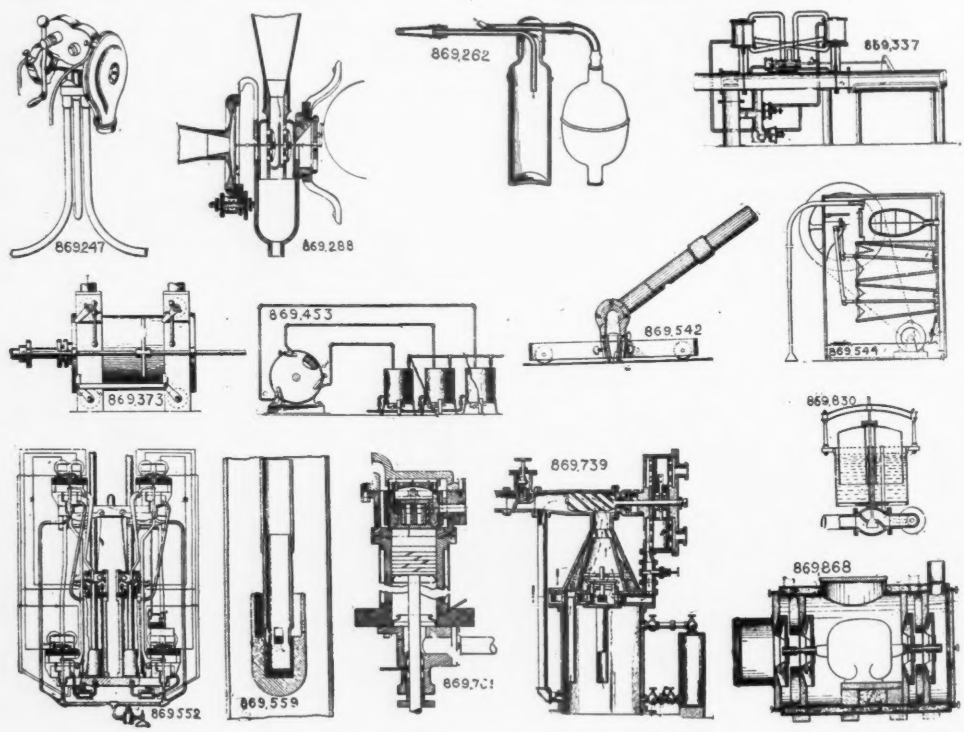
869,559. PUMP. THOMAS FOY, Freehold, N. J.

869,739. AIR-COMPRESSING SYSTEM. ADELBERT SAUER, Pittsburg, Pa.

869,781. PNEUMATIC PUMP. DANIEL L. HOLDEN, New York, N. Y.

869,830. GAS - PRESSURE - REGULATING DEVICE. GUSTAF DALEN, Stockholm, Sweden.

869,868. ORGAN-BLOWING APPARATUS. IRA H. SPENCER, Hartford, Conn.



PNEUMATIC PATENTS, OCTOBER 29.

PORTER COMPRESSED AIR

MINE AND INDUSTRIAL HAULAGE

MORE UP-TO-DATE, SAFER, HANDIER AND MORE RELIABLE AND ECONOMICAL THAN ELECTRICITY

We introduced the first air haulage into anthracite mines, and have installed about 80 per cent. of the air locomotives in America and the majority of those in the world. We can refer to a large number of plants with one to fifteen locomotives, track gauges 18 to 56½ inches. Our designs are automatic, easily controlled and free from complications.

SPECIAL OFFER: On application of Mine Superintendent or prospective user, we will mail free our 233 page catalogue describing 600 steam and 60 air locomotives. To accommodate others a copy will be mailed on receipt of 50 cents in stamps.

Address **H. K. PORTER COMPANY, 1207 Union Bank Bldg., Pittsburg, Pa.**

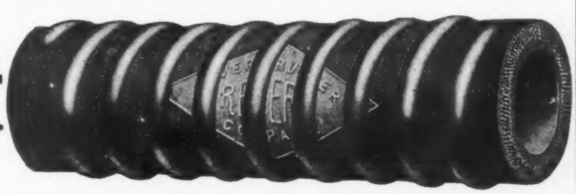
REVERE RUBBER COMPANY,

MANUFACTURERS OF

HOSE FOR PNEUMATIC TOOLS.

Home Office, Boston, Massachusetts.

FACTORIES AT CHELSEA, MASS.



Revere Air Tool Hose.

Branches:

NEW YORK PHILADELPHIA PITTSBURG CHICAGO
MINNEAPOLIS NEW ORLEANS SAN FRANCISCO PORTLAND, ORE.

EVERYONE WHO KNOWS ANYTHING ABOUT THE COAL TRADE KNOWS THAT THE BLACK DIAMOND IS ITS LEADING PAPER.

THE four hundred million tons of coal produced in the United States during the year 1906 were valued at

$600,000,000

at the mines. This will give you an idea of how much money the readers of THE BLACK DIAMOND spent for Mine Machinery and Equipment last year.

If you wish to get your share of this annual expenditure of six hundred million dollars, write for advertising rates.

THE BLACK DIAMOND

New York: 42 Broadway
Chicago: Old Colony Bldg.
Pittsburg: Commonwealth Bldg.
Cincinnati: 117 E. 7th St.
Columbus: Brunson Bldg.

Boxes, Kit and Tool.
Clark Co., W. J.
Brakes, Air.
Westinghouse Air Brake Co.
Castings, Steel.
Curtis & Co. Mfg. Co.
Cableways, Contractors'.
Lidgerwood Mfg. Co.
Channelers.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Charging Stations.
Porter Co., H. K.
Coal Cutters.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Coal Chutes, Steel.
Clark Co., W. J.
Coal and Ore Elevator Buckets.
Clark Co., W. J.
Cocks.
Powell Co., Wm.
Compressors, Air and Gas.
Blaisdell Machinery Co.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Powell Co., Wm.
Rix Compressed Air and Drill Co.
Roteng Engineering Corporation.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.
Compressors, Gasolene Driven.
General Compressed Air and Vacuum Machinery Co.
Compressor Fittings, Air and Gas.
Powell Co., Wm.
Core Drills.
Harrison Supply Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Core Drills, Diamond.
Sullivan Machinery Co.
Core Drills, Diamondless.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Corliss Engines.
Cooper Co., C. & G.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Derricks.
Lidgerwood Mfg. Co.
Drilling Machines, Pneumatic.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Electro-Pneumatic Machinery.
General Compressed Air and Vacuum Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

Engine Room Appliances.
Sargent Steam Meter Co.
Stearns-Roger Mfg. Co.
Fans, Ventilating.
Sprague Electric Co.
Sullivan Machinery Co.
Flue Rolling Machines.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
Foundry Appliances.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Goldschmidt Thermit Co.
Hanna Engineering Works.
Harrison Supply Co.
Ingersoll-Rand Co.
Foundry Facings.
Jos. Dixon Crucible Co.
Graphite Commutator Brushes.
Jos. Dixon Crucible Co.
Graphite Crucibles and Retorts.
Jos. Dixon Crucible Co.
Graphite Greases.
Jos. Dixon Crucible Co.
Graphite Paint.
Jos. Dixon Crucible Co.
Hammer Drills.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Hammers, Calking and Chipping.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Hammers, Riveting.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Helmets, Sand Blast.
C. Druckleib.
Hoisting Machinery.
Lidgerwood Mfg. Co.
Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Hoists, Air.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Hose Clamps.
Clark Co., W. J.
Ingersoll-Rand Co.
Hose Couplings.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Harrison Supply Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Revere Rubber Co.
Rix Compressed Air and Drill Co.

(Continued on page 14.)

Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.

Hose, Steam and Air.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Goodrich Co., The B. F.
Harrison Supply Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Revere Rubber Co.
Rix Compressed Air and Drill Co.
Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

House Cleaning Machinery, Compressed Air.
Blaisdell Machinery Co.
General Compressed Air and Vacuum Machinery Co.
Rix Compressed Air and Drill Co.

House Cleaning Machinery, Vacuum.
Chicago Pneumatic Tool Co.
General Compressed Air and Vacuum Machinery Co.

Locomotives, Compressed Air.
Porter Co., H. K.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.

Lubricating Graphite.
Jos. Dixon Crucible Co.

Lubricating Greases.
Fiske Bros.' Refining Co.

Lubricating Oils.
Chicago Pneumatic Tool Co.
Fiske Bros.' Refining Co.
Ingersoll-Rand Co.

Lubricators.
Powell Co., Wm.

Meters, Steam and Air.
Sargent Steam Meter Co.

Mining Machinery.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Motors, Air.
Cleveland Pneumatic Tool Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
Sargent Steam Meter Co.
Stearns-Roger Mfg. Co.

Nozzles, Air and Sand.
American Diamond Sand Blast Co.
Curtis & Co. Mfg. Co.
Druckleib, C.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.

Oil Cups.
Powell Co., Wm.

Packings.
Green, Tweed & Co.
Revere Rubber Co.

Pile Drivers, Pneumatic.
Ingersoll-Rand Co.
McKiernan Drill Co.

Pipe Joint Compound.
Jos. Dixon Crucible Co.

Plug Drills.
Cleveland Pneumatic Tool Co.

(Continued on page 15.)

Ingersoll-Rand Co.

Pumping Systems, Pneumatic.
Blaisdell Machinery Co.
Bury Compressor Co.
Curtis & Co. Mfg. Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.

Pumps, Air.
Blaisdell Machinery Co.
Cameron Steam Pump Works, A. S.
Chicago Pneumatic Tool Co.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Pneumatic Displacement.
Chicago Pneumatic Tool Co.
General Compressed Air and Vacuum Mcchinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Steam.
Cameron Steam Pump Works, A. S.
Harrison Supply Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Quarrying Machinery.
Blaisdell Machinery Co.
Bury Compressor Co.
Cameron Steam Pump Works, A. S.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Reamers.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Hanna Engineering Works.
Ingersoll-Rand Co.

Riveters.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Hanna Engineering Works.
Ingersoll-Rand Co.

Rock Drills, Air and Steam.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Rock Drills, Electric-Air.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

Sand Blast Machinery.
American Diamond Sand Blast Co.
Druckleib, C.
General Compressed Air and Vacuum Machinery Co.
Harrison Supply Co.
Ingersoll-Rand Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.

(Concluded on page 18.)

Sand Mold Guards, Steel.
W. J. Clark Co.
Sand Sifters.
Hanna Engineering Works.
Ingersoll-Rand Co.
Stone Tools, Pneumatic.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Harrison Supply Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Tapping Machines.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
Thermit.
Goldschmidt Thermit Co.
Tools, Pneumatic.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Harrison Supply Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Valves, Air Blow Gear.
Powell Co., Wm.
Wheels, Pressed Steel Truck,
Clark Co., W. J.
Welding Appliances.
Goldschmidt Thermit Co.
Wood Boring Machines, Pneumatic.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

1907

al

72

I

F
S